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No. 80

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CONTENTS

AERONAUTICAL AND SPACE

Shutdown Impulse of Liquid-Propellant Rocket Engine and Its Dispersion 1

NUCLEAR ENERGY

New Thermonuclear Facility 2

Monitoring Energy Distribution in VVER-440 Core 4

Reducing Atmospheric Discharge of Radioactive Gases From VVR-M Reactor 4

Investigating Resonance Neutron Absorption in Fuel of High-Temperature Graphite Reactor 5

Investigating Vapor Effects and Reactivity Coefficients of Beloyarskaya Atomic Power Plant Reactors 5

Experimental Atomic Heating Plant Based on Arbus Reactor 6

Optimizing Steam Parameters of Nuclear Electric Plant With Water-Graphite Channel Reactors Under Conditions of Rising Costs of Replaced Electric Energy 6

Power Regulation of Turbine Installations in Two-Circuit Nuclear Electric Plants 7

Safety Valve in Primary Circuit of Nuclear Power Plant With VVER Reactor 7

NON-NUCLEAR ENERGY

Role of Tunnel-Thin Dielectric Layer in Solar Energy Converters With 'Metal Oxide - Silicon Oxide - Silicon' Structure 9

Composition and Structure of CdTe High-Voltage Photovoltaic Cells. 9

Heat Balance in Shielding Structure With Thermoelectric Cooling Device 10

Calculating Refrigerating Capacity of Solar Refrigeration Plants . . . 10

Determining Optimum Height of Cells in Thermoelectric Batteries With Effect of Electrical Contacts Taken Into Account. 11

Determining Optimum Radiation Concentration Factors and Concentrator System Parameters for Solar Batteries With Radiative Heat Dissipation. 12

Calculating Grounding Systems for Industrial Complexes in Regions of the Far North 12

Maximum Permissible Temperature Conditions for Components of Electric Equipment. 13

INDUSTRIAL TECHNOLOGY

Mathematical Model of Piezoelectric Motor in Start-Stop Mode 14

Decomposition in Controlled Dynamic Systems. 18

Reducing Noise in Chain Transmissions. 18

Characteristics of Hydrodynamic Journal Bearings With Spiral Grooves in Coaxial Alignment of Shaft and Bushing. 19

Calculating Load Capacity of Radial Gas Bearings With Discrete Gas Blasting 19

Synthesizing Control for Programmed Motion of Automatic Manipulators . 20

Methods of Controlling Movement of Automatic Manipulator Elements. . . 20

Investigating Productivity of Automatic Lines by Computer Simulation . 21

New Elastic Robot Manipulator Grips. 22

Calculating Coordinate of Onset of Pneumatic Drive Piston Braking in Industrial Robot 23

Determining Maximum Velocity Trajectories of Cycle Travel of Hydraulically Actuated Robot Arm 23

Electrohydraulic Drive for Rotating Tool Holder of Forging Manipulator. 24

Active Damping of Mechanical Systems 24

Optimization of Active Vibroprotection Device. 25

Industrial Minirobots of Modular Design With Discrete Pneumatic Drive. 25

Manipulator With Pneumoacoustic Outside Information Pickup 26

Using Industrial Robots To Automate Multipass Sheet Stamping 26

Probe Manipulators for Studying Semiconductor Materials and Structures on Plates. 27

TURBINE AND ENGINE DESIGN

Analysis and Improvement of Gas Exhaust Pipe With Elbow Fitting for Turboprop Engines. 28

Excitation of Surge-Like Vibrations by Aperiodic External Action . . . 28

Thermodynamic Analysis for Comparing Efficiencies of Semiclosed and Open Air Cooling Systems for Gas Turbine Engines 29

Distinguishing Design Features of Hydrogen-Vapor Propulsion Turbines . 29

General Approach to Optimizing Diesel Engine Based on Its Mathematical Model 30

Complex Studies of Inner Loop of Engine With Closed Regenerative Cycle. 31

Optimizing Angle of Injection Onset in Diesel Engines. 31

Enhancing Economy of Combined Motors and Power Turbines. 32

Using Balls for Automatic Elimination of Dynamic Rotor Imbalance . . . 32

Effectiveness of Using Compressor Guide Vanes With Cantilever Blades . 33

Variation of Static Pressure at Revolving Blades of Axial-Flow Compressor During Surging. 33

Damping Tangential Vibrations of Turbine Blades by Using Shrouds With Corrugated Bands. 34

NAVIGATION AND GUIDANCE SYSTEMS

Two-Stage Automatic Ground Gyrocompass 35

Choosing Optimum Parameters of Celestial Direction Finder by Standard Program 36

Using Recurrent Search Evaluation for Correcting Inertial Systems With Respect to Relief Field 36

FLUID MECHANICS

Calculating Flow of Liquid Through Passageways in Radial Hydrostatic Bearing by Finite Element Method 37

Criteria of Separation and Supplementary Equation for Three-Dimensional Turbulent Boundary Layer at Revolving Blade. 37

Experimental Study of Heat Transfer at Surface of Moving Turbine Blades 38

Calculating Parameters of Combustion Process in Reactor With Complete Mixing. 38

Aerodynamic Damping of Blade Vibrations in Reaction Turbine Stages . . 39

Some Problems of Solid Body Penetration Into Ponderable Fluid. 40

Experimental Study of Pattern of Boundary Flow in Stream With Initial Twist. 40

Development and Experimental Study of New Aerodynamically Improved Subsonic Turbine Blade Profiles. 41

Motion of Finely Dispersed Inclusions in Vibrating Vessel With Liquid Containing Compressible Sphere. 41

MECHANICS OF SOLIDS

Asymptotic Integration of Thermoelasticity Equations for Conical Shell of Variable Thickness. 43

Design of Reticular Shells of Revolution 43

Resonance Vibrations of Shell With Intricate Outline Resulting From Bending Boundary of Ellipsoid of Revolution. 44

Optimal Control of Stress and Strain State for Viscoelastic Cylindrical Shell. 45

Three-Dimensional Problems in Theory of Elasticity for Multilayer Shells With Nearly Spherical Interfaces 45

Numerical Methods of Analyzing State of Stress and Strain and Life of Disks in Gas-Turbine Aircraft Engines. 46

State of Stress and Strain of Spherical Shell Under Nonsteady Wind Load. 46

Effect of Service in Corrosive Medium on Compressor Blade Endurance in Gas-Turbine Engine. 47

State of Stress of Chromium Stainless Steel Gas-Turbine Blades 48

Resonance Transitions of Rotors in Elastic Damper Bearings 48

Asymptotic Approximations for Solving Vibration Equations for Spherical Shells 49

Optimizing Escapement Mechanisms 49

Effect of Normal Vibrations on Friction Force Magnitude. 50

Identification of Mechanical Oscillating Systems 50

Calculating Shells of Revolution by Finite Element Method. 51

Designing Shells of Minimum Weight and Given Volume. 51

Boundary-Value Conditions at Pole of Shell of Revolution During Computer Calculation 52

Analysis of Two Methods of Local Deformation 52

Analysis of Turbine Blade High-Frequency Vibrations by Methods of 'Sliding Support' and Holographic Interferometry 53

Stressed State of Cylindrical Tank With Tangential Branch Pipe Under Action of Internal Pressure. 53

Selecting Rational Parameters of Reinforcement of Cylindrical Shell in Zone of Concentrated Action 54

Theory of Coupled Thermoelasticity of Two-Component Mixtures 55

Forced Oscillations of Viscoelastic Cylinder Reinforced by Shell With Annular Ribs 56

Elastic Deformation and Slipping of Layers of Cylindrical Shell Formed by Coiling Under Loading by Internal Pressure 56

Free Oscillations of Ribbed Cylindrical Shell With Frame 57

Stability of Cylindrical Shell Interacting Unilaterally With Winkler Base 57

Investigating Stressed State of Shear-Compliant Cylindrical Shells of Arbitrary Cross Section 58

Analyzing Computational Schemes for Shells of Composite Materials With Openings. 59

Natural Oscillations of Laminar Anisotropic Plates and Shallow Shells. 60

Numerical Calculation of Piezoceramic Shells of Revolution 60

Stressed State in Vicinity of Cylindrical Shell Intersection 61

Choosing Main Parameters of Inclined Vibrating Screens With Circular Oscillations. 61

TESTING AND MATERIALS

Technological Feasibility Study of Using Titanium Nickelide for New Types of Permanent Pipeline Joints 63

Cyclohexyl Nitrate: Fuel Additive for Diesel Engines. 64

Changes in Spectral Reflection Capacity and Integral Absorption Coefficient of TiO_2 Powder Under Simulated Solar Radiation 64

Metrology of Solar Cells 65

UDC 629.7.036.54-64.536.46

SHUTDOWN IMPULSE OF LIQUID-PROPELLANT ROCKET ENGINE AND ITS DISPERSION

Kazan' IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 81 (manuscript received 20 Jun 79) pp 41-44

PRISNYAKOV, V. F.

[Abstract] Attainment of the required final velocity of a rocket depends largely on an accurate determination of the engine shutdown impulse and its statistical dispersion. Here this is done by an analysis of four successive stages in the shutdown process: 1. delay in the response of the combustion chamber to the shutdown command (no change in the thrust), 2. closure of the valves (the fastest closing valve determines the length of this stage), 3. sharp drop of the pressure in the combustion chamber, 4. boilout of still liquid ingredients in spaces behind the valves. The corresponding components of the shutdown impulse are calculated on the basis of applicable thrust and time relations, including the statistical characteristics of both parameters during each stage and disregarding the effects of the preceding stage on each succeeding one. The calculations involve also volume changes, pressure changes, and temperatures as well as their dispersions. A theorem of the correlation function for the integral of a random function is applied to the last component of the shutdown impulse (stage 4 of the shutdown process). Figure 1, references 2 Russian.
[197-2415]

NUCLEAR ENERGY

NEW THERMONUCLEAR FACILITY

Moscow KRASNAYA ZVEZDA in Russian 4 Mar 81 p 4

[Article by D. Panov, candidate of physical and mathematical sciences]

> [Text] The new Ogra-4 experimental fusion facility has been put into physical operation at the Institute of Atomic Energy imeni I. V. Kurchatov.

Intensive research is being done in the Soviet Union in the field of power based on controlled nuclear fusion--combustion of a mixture of the hydrogen isotopes deuterium and tritium. The raw material base of this source is unlimited.

To master the reaction of controlled nuclear fusion, it is necessary to heat plasma to a temperature of more than 100 million degrees, compress it to high density, and hold it in this state long enough for nuclear interaction.

In facilities of the Tokamak and Ogra type, the plasma is confined by a magnetic field. There is a significant difference between the facilities: in tokamaks, the lines of force are closed inside a toroidal vacuum chamber; in the Ogra, the lines of force go beyond the walls of the chamber, and therefore facilities of this type are called open.

The development of thermonuclear reactors based on open plasma traps has been going on for some time, and considerable scientific material has been acquired in this field. However, for years the plasma confinement time in an isolated trap has been short, raising questions of ensuring economic characteristics of a power reactor that would justify its development and manufacture.

This situation changed radically a few years ago when it was proposed at the Institute of Nuclear Physics of the Siberian Department of the USSR Academy of Sciences that plasma confinement could be improved by adding magnetic "mirrors" to the conventional trap.

The Ogra-4 will enable accumulation and confinement of plasma with high energy parameters. The magnetic field of the trap is produced by a superconductive winding cooled to liquid helium temperature (4.2 kelvins). Its weight including the power frame is five metric tons. A current of more than 2000 amperes flows through conductors with cross section of about 0.4 sq. cm. We add that the field of such a magnet is stationary, and that it is fed by a small generator with a potential of a few volts. The magnetic field strength of the trap reaches 40 kilogauss in the vicinity of plasma confinement, and up to 60 kilogauss on the surface of the winding.

The plasma in the trap is formed by an intense beam of fast hydrogen atoms. To get this intense atomic beam, there are four ion sources on the injector chamber of the Ogra-4 that were developed at the Institute of Atomic Energy imeni I. V. Kurchatov. In these ion sources, a discharge is ignited with current of up to 1000 amperes, and a focused beam of ions of the necessary energy is extracted from the gas discharge by a precision system of high-voltage lenses. As they pass through the rarefied gas cloud, these ions capture electrons from the neutral gas molecules, and are injected into the trap in the form of fast neutral atoms.

A special device has produced a cold plasma flow in the trap beforehand. As the fast atoms collide with the particles of this plasma, they "fall apart" into ions and electrons that accumulate to form a high-temperature plasma.

Implementation of this entire process requires the use of systems with high parameters, often pushing technical capabilities to the limit for manufacture and adjustment. For example, stresses arise in the magnet system that are measured in the hundreds of tons, and that must be completely compensated. At the same time, the windings have to be fastened so securely that shifts do not exceed a fraction of a millimeter. In addition, the vacuum conditions must be ultraclean for plasma confinement.

The Ogra-4 provides the capability of entering a new region of plasma parameters close to thermonuclear reactor conditions. The program of experimental research envisioned for the facility will provide data necessary for taking the next step on the path to conquest of controlled nuclear fusion.

6610
CSO: 1861/205

UDC 621.039.524.44:521:0.39.56

MONITORING ENERGY DISTRIBUTION IN VVER-440 CORE

Moscow ATOMNAYA ENERGIYA in Russian Vol 50, No 6, Jun 81 (manuscript received 8 Sep 80) pp 423-425

BOGACHEK, L. N., GAZARYAN, K. A., LYSENKO, V. V., MUSORIN, A. I., PAVLOV, V. I., PARSADANYAN, M. M., RYMARENKO, A. I., SAAKOV, E. S., SIMONOV, V. D., STAVTSEV, Ye.P., TSYPIN, S. G. and SHMONDIN, V. A.

[Abstract] The energy distribution in the core of the VVER-440 reactor was monitored by the energy removed by the coolant of the corresponding circulating loops in six sectors of the core. Two methods were used to determine the thermal energy in the loops of the in-pile circuit, the first of which is based on measuring the temperature difference of the coolant in the hot and cold sections of the circulating loops by standard thermocouples and the second of which is related to recording the gamma radiation of nitrogen from sensors designed to determine the coolant flow rate in the loops. Variation of energy release in the core through which the coolant from a given loop circulates was determined as a function of the neutron flux density. The experimental values of variation of the circulation loops caused by deformation of the energy distribution in the core were comparable to the calculated variation of energy release in the sectors. Figure 1, references 3 Russian.
[187A-6521]

UDC 621.039.76

REDUCING ATMOSPHERIC DISCHARGE OF RADIOACTIVE GASES FROM VVR-M REACTOR

Moscow ATOMNAYA ENERGIYA in Russian Vol 50, No 6, Jun 81 (manuscript received 20 May 80) pp 414-415

KONOVALOV, Ye. A., KONOPLEV, K. A., PIKULIK, R. G., PLOSHCHANSKIY, L. M., RAZOV, B. S. and SAYKOV, Yu. P.

[Abstract] Simple, effective and inexpensive means of reducing radioactive gas emissions into the atmosphere from the VVR-M reactor were investigated during modernization of the reactor to increase output from 16 to 30 MW. The ratio of

the rate of discharge of gases from the coolant to the rate of generation was investigated as a factor that affects the emission of radioactive gases. This emission was reduced by reducing the open surface of the coolant and by increasing the thickness of the diffusion layer by placing a floating polyethylene diaphragm 700 mm thick in the reactor vessel. Discharge of the aerosol component was reduced by reducing the discharge of gaseous precursors and by removing the isotopes contained in the aerosols from the water of the primary circuit by using purification filters. References 3 Russian.
[187A-6521]

UDC 621.039.524.2.034.3.077

INVESTIGATING RESONANCE NEUTRON ABSORPTION IN FUEL OF HIGH-TEMPERATURE GRAPHITE REACTOR

Moscow ATOMNAYA ENERGIYA in Russian Vol 50, No 6, Jun 81 (manuscript received 28 May 80) pp 387-390

BUSHUYEV, A. V., DUVANOV, V. M., KOZHIN, A. F., ZUBAREV, V. N., NAUMOV, V. I. and BELOUSOV, N. I.

[Abstract] Resonance absorption of neutrons in the fuel of a high-temperature graphite reactor was investigated experimentally as a function of microfuel element mass. The dependence of the resonance integral of the microfuel element on temperature was investigated in the range of 300-1,500 K. The dependence of the resonance integral of a spherical fuel element on uranium content was determined with carbon and uranium concentrations from 500 to 1,500. The calculating methods that utilize the equivalence relation was substantiated experimentally to describe resonance absorption of neutrons in the fuel of these reactors. Figure 1, references 4: 3 Russian, 1 Western.
[187A-6521]

UDC 621.039.514:621.039.519

INVESTIGATING VAPOR EFFECTS AND REACTIVITY COEFFICIENTS OF BELOYARSKAYA ATOMIC POWER PLANT REACTORS

Moscow ATOMNAYA ENERGIYA in Russian Vol 50, No 6, Jun 81 (manuscript received 8 Jan 79) pp 281-284

ANDREYEV, V. P., BONDARENKO, A. V., VIKULOV, V. K., KOZYREV, V. D., KRASNOGOROV, F. M., LYUBCHENKO, V. F., MAL'TSEV, V. V., MITYAYEV, Yu. I., OVESHKOV, A. S., SNITKO, E. I., SHEYNKMAN, A. G. and SHIROKOV, S. V.

[Abstract] The vapor coefficient of reactivity defined as the ratio of the effective reactivity to variation of the mean volumetric vapor content was investigated in boiling fuel channels with variation of the coolant flow rate

in the primary circuit of the reactor. Measurements of the vapor coefficient in two reactors show a significant variation from measurement to measurement. If the flow rate of the coolant is reduced, the vapor coefficient was positive for both reactors and was dependent on the ratio of the number of fuel channels in the core and on the height distribution of the neutron flux density. The effects of reactivity increase as water is removed from the fuel channel with an increase of fuel burnup. Figure 1.
[187A-6521]

UDC 621.039.524

EXPERIMENTAL ATOMIC HEATING PLANT BASED ON ARBUS REACTOR

Moscow ATOMNAYA ENERGIYA in Russian Vol 50, No 6, Jun 81 (manuscript received 15 Jun 80) pp 376-381

TSYKANOV, V. A., CHECHETKIN, Yu. V., KORMUCHKIN, Yu. P., POLIVANOV, I. F., POCHECHURA, V. P., YAKSHIN, Ye. K., MAKIN, R. S., ROZHDESTVENSKAYA, L. N. and BUNTUSHKIN, V. P.

[Abstract] The problems and prospects of using an experimental atomic heating plant based on the Arbus reactor with organic coolant were investigated. An experiment to convert the Arbus installation from the atomic power plant to the atomic heating plant modes was described. Gas oil, hydroterphenyl and ditolyl methane were used as the organic coolants. The low pressure of the coolant vapor and the low corrosion activity permit successful use of thin-walled pipe and carbon steel equipment for the primary circuit. Experimental operation of the plant showed simplicity and convenience of operation and a high degree of safety due to a reduction of pressure from the heating system to the reactor. Figures 3.
[187A-6521]

UDC 621.311.25:621.031-97/98

OPTIMIZING STEAM PARAMETERS OF NUCLEAR ELECTRIC PLANT WITH WATER-GRAPHITE CHANNEL REACTORS UNDER CONDITIONS OF RISING COSTS OF REPLACED ELECTRIC ENERGY

Minsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ENERGETIKA in Russian No 3, Mar 81 (manuscript received 30 Dec 80) pp 35-40

GEL'TMAN, A. E. and TARASYUK, A. F., candidates of technical sciences, Scientific Production Association of the Central Scientific Research Design and Planning Boiler and Turbine institute imeni I. I. Polzunov

[Abstract] The rising cost of electric energy produced by fossil-fuel plants is important in choosing the parameters of power-producing equipment. In this paper the authors examine this question in application to optimizing the initial

parameters of steam in nuclear electric plants with water-graphite channel reactors. As a result of the analysis it is concluded that in the outlook for 1990-2000 it should be feasible to increase the optimum steam pressure in nuclear electric plants with RBMK-P reactors to 10-12 MPa with nuclear superheating of live steam to 450° C. The resultant annual savings should be 0.13-0.20 rubles/MWh, i.e. 900-1400 rubles/MWyr under the conditions of a nuclear electric plant, and 0.37-0.47 rubles/MWh or 2600-3300 rubles/MWyr under conditions of a nuclear TETs. Figures 2, references 3 Russian.
[179-6610]

UDC 621.311.25:621.039.001.13

POWER REGULATION OF TURBINE INSTALLATIONS IN TWO-CIRCUIT NUCLEAR ELECTRIC PLANTS

Minsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ENERGETIKA in Russian No 3, Mar 81 (manuscript received 24 Dec 79) pp 111-112

KHRUSTALEV, V. A., candidate of technical sciences, docent, and DANILOV, P. V., engineer, Saratov "Order of the Red Banner of Labor" Polytechnical Institute

[Abstract] A method is proposed for comparing different methods of controlling the load of steam-raising units in two-circuit generating facilities of nuclear electric plants with respect to normalized expenditures. It is shown that it is effective to maintain water temperature in the reactor constant during variations in working conditions. With a reduction in the effective duration of a run from 6,000 to 4,000 hours per year, the savings resulting from the proposed method of regulation can reach from 180,000 to 240,000 rubles per year for a 1,000 MW generating facility. Figures 2, references 2 Russian.
[179-6610]

UDC 621.039.587

SAFETY VALVE IN PRIMARY CIRCUIT OF NUCLEAR POWER PLANT WITH VVER REACTOR

Moscow ATOMNAYA ENERGIYA in Russian Vol 50, No 5, May 81 pp 308-310

MITENKOV, F. M., ZVEREVA, L. A., MOTOROV, B. I., MEL'NIKOV, E. M. and SAMOYLOV, O. B.

[Abstract] An analysis is made of methods of reliable protection of the primary circuit of nuclear power plants from pressure above the permissible level. Accidents that may lead to a pressure rise are considered. One cause of pressure increase may be accumulation of excess heat due to interruption of coolant circulation in the primary circuit, interruption of the supply of feed water to the steam-raising units, power excursion, fire, and also malfunctioning of the water makeup system. A failure in the makeup system can be easily eliminated by a relief

valve in the primary circuit makeup pump that guarantees that the pressure will not exceed the permissible value. Cumulative heating in the first circuit can be prevented by installing backup protection, control and signal equipment, redundancy to ensure protective operation with respect to deviation of certain dependent, independent and related cause-and-effect parameters, multichannel measurement circuits, independent panels, routings and sources of electric supply with territorial separation, auxiliary lines for supply of feed water to the cooling systems, and the availability of several cooling channels, water storage tanks and so on. Some accidents are considered and the means used to meet emergencies in these cases are described. The reliability of the proposed measures has been verified by operational utilization on marine power plants and nuclear electric power plants. Figure 1, references 4: 1 Russian, 3 Western.
[192-6610]

UDC 621.472:621.383.5

ROLE OF TUNNEL-THIN DIELECTRIC LAYER IN SOLAR ENERGY CONVERTERS WITH 'METAL OXIDE - SILICON OXIDE - SILICON' STRUCTURE

Tashkent GELIOTEKHNIKA in Russian No 3, May-Jun 81 (manuscript received 22 May 80) pp 72-74

MALIK, A. I., MANASSON, V. A. and BARANYUK, V. B., Chernovtsy Branch of Semiconductor Materials Science, Institute of Applied Problems in Mechanics and Mathematics, UkSSR Academy of Sciences

[Abstract] The conversion coefficient of solar cells with a "metal oxide - silicon oxide - silicon" structure can be substantially increased by insertion of an intermediate dielectric layer. The mechanism of this effect involves additional segregation of photocarriers in this layer due to different respective tunneling probabilities for majority and minority carriers. In this study the current-voltage characteristic of SnO_2/In_2O_2-SiO_x-nSi solar cells was measured by an earlier developed method in both the active region and the neutral region with dielectric layers of various thicknesses. The open-circuit voltage was found to increase with increasing thickness of the dielectric layer, but the slope of the current-voltage characteristic for the active region was found to be independent of thickness. The results indicate that segregation of photocarriers occurs only within the space charge region of the semiconductor, while the region containing the dielectric layer remains neutral. Figures 2, references 11: 4 Russian, 7 Western.
[187-2415]

UDC 621.382.2

COMPOSITION AND STRUCTURE OF CdTe HIGH-VOLTAGE PHOTOVOLTAIC CELLS

Tashkent GELIOTEKHNIKA in Russian No 3, May-Jun 81 (manuscript received 15 Apr 81) pp 67-68

ATAKULOV, B. A., AFUZOV, A. Ya., BILYALOV, E. I. and SVIRIDOV, V. M., Fergana State Pedagogical Institute imeni Ulugbek

[Abstract] The composition and structure of CdTe-film high-voltage photovoltaic cells, produced by the method of discrete evaporation, was studied by means of space modulation of their reflection spectra and comparing the latter with

already known electrical-reflection spectra of CdTe single crystals. The results reveal a sharp 0.9 eV peak above the 2.38-2.48 eV level within the 0.5-0.52 μm range of wavelengths due to band-band transition and a soft shoulder near the 0.653 m wavelength due to the presence of free metal (cadmium), also an anomalous 0.4 eV upward shift of the optical-absorption edge near the 0.96 μm wavelength due to the presence of amorphous semiconductor (cadmium telluride). The oscillations of such modulated spectra, without a distinct resonance, are attributable to internal electric fields in the device structure with active inhomogeneities forming chains of micropotential barriers. Figure 1, references 8 Russian.
[187-2415]

UDC 662.997.004.14

HEAT BALANCE IN SHIELDING STRUCTURE WITH THERMOELECTRIC COOLING DEVICE

Tashkent GELIOTEKHNIKA in Russian No 3, May-Jun 81 (manuscript received 15 Jan 79) pp 63-66

SOLDATOV, Ye. A. and KAKHAROV, U. K., Samarkand Architectural Engineering Institute imeni Ulugbek

[Abstract] The heat balance in a shielding structure with a thermoelectric cooling or heating device is interrelated with the heat balance at its outside and inside surfaces as well as with the heat transfer through the device. For engineering design purposes, the corresponding equations are formulated and expressions derived from them which yield either the maximum temperature drop from outside to inside that a given thermoelectric battery can ensure, or the necessary refrigerating capacity of such a battery to ensure a given temperature difference. Figure 1, references 3 Russian.
[187-2415]

UDC 662.997:662.995

CALCULATING REFRIGERATING CAPACITY OF SOLAR REFRIGERATION PLANTS

Tashkent GELIOTEKHNIKA in Russian No 3, May-Jun 81 (manuscript received 20 Jan 81) pp 59-62

ACHILOV, B. M. and CHUGUNKOV, V. V., Bukhara State Pedagogical Institute imeni S. Ordzhonikidze

[Abstract] Absorption-type solar refrigeration plants are being installed in the southern republics of the Soviet Union. The refrigerating capacity of such plants is calculated from the equations of heat balance for the condenser and the evaporator, assuming also that $P = \frac{\rho}{\mu} RT$ (ρ - vapor density of the working substance, μ - mass/kmole of the coolant) for the pressure in the generator and the approximate empirical relation $\rho = 0.005\ T^{1.6}$ kg/m^3 hold true within the

20-120° C temperature range. This calculation also involves the dependence of the mass of liquid in the condenser on the mean temperature drop across the latter, and the integral mass of vapor produced in the evaporator during the process. The result is a simple expression for the refrigerating capacity, $Q = K_e S_e (t_{ar} - t_c)$ (K_e - coefficient of heat transfer in the evaporator, S_e - surface area of the evaporator, t_{ar} - mean air temperature in the refrigerator chamber, t_c - temperature of the condenser). The variation of the plant performance characteristics over a 24 h period has been calculated on this basis for a KhAB-120 solar refrigerator. The agreement with experimental data is satisfactory, taking into account diurnal fluctuations of the ambient temperature and the solar radiant flux. Figures 3, reference 1 Russian.
[187-2415]

UDC 621.362

DETERMINING OPTIMUM HEIGHT OF CELLS IN THERMOELECTRIC BATTERIES WITH EFFECT OF ELECTRICAL CONTACTS TAKEN INTO ACCOUNT

Tashkent GELIOTEKHNIKA in Russian No 3, May-Jun 81 (manuscript received 10 Apr 80) pp 35-37

PLEKHOTKIN, V. P., TKACHENKO, M. F., MELIKHOVA, T. M. and BONDAREVSKAYA, L. A., Ukrainian Scientific Research Institute of Gases, USSR Ministry of the Gas Industry

[Abstract] Although it apparently seems possible to increase the refrigerating capacity of a thermoelectric battery infinitely and simultaneously decrease its size and weight, a limitation is imposed here by the increasing thermal flux density in cold as well as hot junctions: it can increase so much as to exceed the heat dissipation capabilities. It thus becomes necessary to determine the optimum dimension (height) of a thermoelectric cell, taking into account the electrical resistance of the contacts. This is done here on the basis of the fundamental equation of heat balance, which yields expressions for the refrigerating capacity and for its two derivatives: one with respect to the electric current and one with respect to the cell height. Numerical data obtained for typical design and performance parameters indicate that, for maximum refrigerating capacity, the height should be 1-2.5 mm depending on the neeessary temperature drop. The heat dissipation capability will determine the optimum current. Table 1, references 2 Russian.
[187-2415]

UDC 662.997:662.93

DETERMINING OPTIMUM RADIATION CONCENTRATION FACTORS AND CONCENTRATOR SYSTEM PARAMETERS FOR SOLAR BATTERIES WITH RADIATIVE HEAT DISSIPATION

Tashkent GELIOTEKHNIKA in Russian No 3, May-Jun 81 (manuscript received 11 Oct 80) pp 19-24

GRILIKHES, V. A., ZAYTSEV, O. F. and MEN'SHIKOV, Ye. M., Leningrad

[Abstract] A system of three equations is used as a basis for determining the optimum solar radiation concentration factor corresponding to maximum specific power (per unit surface area) of solar cells. These equations describe respectively the proportionality relation between the specific electric power and the energy concentration factor, the approximately linear dependence of the cell efficiency on the cell temperature within the operating range, and the Stefan-Boltzmann fourth-power relation between the temperature of the solar cell and the radiative heat dissipation. On this basis, and taking into account various design limitations, the economic payoff of using concentrators is evaluated in terms of minimum mass and cost of solar batteries. Solar batteries of Si cells and solar batteries of GaAlAs heterojunction photocells with and without concentrators are compared. The use of concentrators is found to be most effective in solar power systems with GaAlAs devices, where an extra benefit in terms of additional operating capacity can be derived from the self-annealing of radiative defects at an energy concentration factor within the $K_E \approx 5$-6 range. Figures 3, tables 1, references 12: 11 Russian, 1 Western.
[187-2415]

UDC 621.316.995.001.24

CALCULATING GROUNDING SYSTEMS FOR INDUSTRIAL COMPLEXES IN REGIONS OF THE FAR NORTH

Moscow PROMYSHLENNAYA ENERGETIKA in Russian No 6, Jun 81 pp 34-38

ASEYEV, G. G., candidate of technical sciences, Noril'sk Evening Industrial Institute

[Abstract] The removal of electric potential is a key factor governing electrical safety conditions; contact voltages in metal underground lines can be considerably higher than the step voltage and contact voltage in the area of a substation. The dimensions of the natural grounding system and of metallic coupling with industrial underground lines increase along with the development of industrial enterprises and result in a reduction of the input impedance of the grounding system. This input impedance tends toward a constant value at its limit, i.e., toward the wave impedance of the limit grounding electrode, which is a plate whose area is equal to the area of the overall grid. Data are presented on the development of the grounding system and power system of an industrial complex during the period 1970-1980, indicating that the real dimensions of the natural grounding system are already greater than the maximum permissible. It is economically

unfeasible and often technically unfeasible to install artificial grounding devices. Existing procedures for calculating the values and the distribution of contact voltages in a complicated grounding system of an industrial complex are cumbersome and complex for planning organizations. On the basis of studies indicating that the representation of the geoelectrical cross section in regions of the far north as a two- or three-layer structure is quite arbitrary, whereas in actuality multilayer structures are characteristic, it is suggested that the real ground structure be made equivalent to a simplified calculation cross section representing a homogeneous structure, whereby the calculation parameter is the equivalent resistivity, the calculation of which differs for extended grounds as compared with calculations made by the electrostatic method. It is demonstrated that large grounding systems of industrial complexes should be calculated by taking into account the influence of distributed parameters, such as resistance and inductive impedance. Simplified calculation models of complex grounds can be used; an equivalent surface plate, in particular. Conditions of single-phase short circuiting in the electrical network must be reproduced with the greatest possible accuracy in making an experimental check of calculation data. An equation is presented for determining the minimum value of the input potential, with a fixed value of the calculation current, at the single-phase short-circuit point. The problem of electrical safety is especially important in regions of the far north because of the high resistivity of the soil structure and of the large-scale construction of power-intensive non-ferrous metallurgy enterprises and the development of electric power. It is feared that the present method of estimating and ensuring the required level of electrical safety will prove to be inadequate. Figures 3, references 7 Russian.
[196-8831]

UDC 621.311.22:539.4.012.2

MAXIMUM PERMISSIBLE TEMPERATURE CONDITIONS FOR COMPONENTS OF ELECTRIC EQUIPMENT

Minsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ENERGETIKA in Russian No 3, Mar 81 (manuscript received 8 Apr 80) pp 67-71

LYUBIN, A. G., engineer, Khmel'nitskiy Technological Institute of Everyday Services

[Abstract] Starting of power units involves considerable stresses due to rapid heating. To minimize starting time, it is helpful to determine the temperature conditions that would make the temperature stresses on the heating surface equal to the maximum permissible value. The exact solutions to the problem that have been given in the literature are difficult to apply in engineering practice. An approximate method has been proposed previously by the author with V. M. Vigak for determining optimum temperature conditions for steam lines. In this paper the first approximate expressions are found for maximum permissible conditions for components of energy-producing equipment that can be represented by a plate and a hollow sphere. A specific numerical example is given. The expressions derived in the paper can be used effectively in engineering calculations of the starting conditions of power units. Figure 1, references 6 Russian.
[179-6610]

UDC 621.313.13+621.389+537.228

MATHEMATICAL MODEL OF PIEZOELECTRIC MOTOR IN START-STOP MODE

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian
Vol 24, No 4, Apr 81 (manuscript received 16 Jun 80) pp 26-29

[Article by A. A. Tikhonov, Leningrad Institute of Precision Mechanics and Optics]

[Text] The author considers an approximate mathematical model of a piezoelectric motor in the state of acceleration, deceleration and damping of natural oscillations.

Some problems of present-day instrument making that require precise high-speed microdisplacement of movable elements in the start-stop mode are difficult to solve without using a piezoelectric motor. In reversible start-stop operation it is preferable to use a piezoelectric motor with zero contact angle, which is the case considered in this paper.

The piezoelectric motor is a piezoelectric crystal plate that carries a friction shoe. An elastic element that acts on the piezoelectric crystal plate presses the friction shoe against the rotor of the unit. When voltages are applied to the electrodes of the piezoelectric crystal plate, longitudinal and flexural independent oscillations arise [see References]. The trajectory of motion of the friction shoe depends on the frequency and phase shift of the supply voltages. In this connection, the friction shoe is periodically pressed against the rotor and gives a force pulse. Although we will be discussing a linear motor, everything said here is valid with obvious modifications for piezoelectric motors with rotary motion as well.

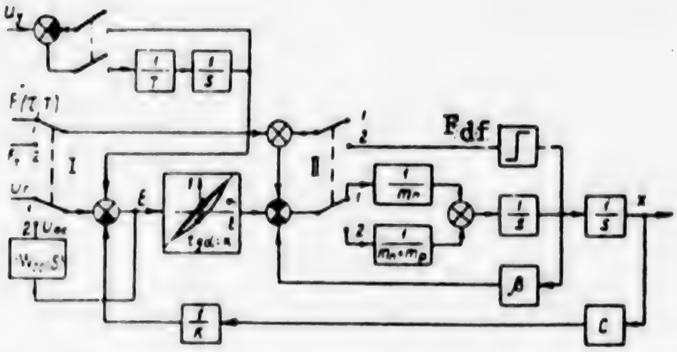
Speed of action is a fairly general criterion for automatic devices that must provide precision operation in minimum time. With respect to the conditions of the problem we can formulate major requirements to be met by piezoelectric motors in the stop-start mode: maximum forces of acceleration and deceleration; maximum rigidity of fastening of the piezoelectric crystal plate in the longitudinal direction, which can be technically accomplished for example by fastening in a longitudinal motion assembly; capability of measuring parameters of excitation of the piezoelectric crystal plate for the purpose of organizing damping of natural oscillations during and after braking until the rotor comes to a complete stop. A sequence of force pulses acts on the rotor starting from the instant when voltages are applied to the piezoelectric crystal plate. For practical purposes, the delay of excitation of oscillations can be disregarded at a supply voltage frequency f equal to a few tens of kilohertz. If we assume that the force of friction does not depend on the slipping rate, all pulses in the process of acceleration of the rotor should be equal. However, for a number of reasons, chief among which is the state of the microrelief of the friction shoe and the rotor, these pulses are not the same. This effect can be described by a coefficient of friction of the friction shoe against the rotor, k_c, which in the frequency range $\pm f_k$ can be represented as white noise of intensity $N_k = \sigma^2 (2f_k)^{-1}$ centered relative to mathematical expectation k_0. The equation that describes the process of acceleration can be written as

$$m_p \ddot{z} = (k_0 + k_c) \sum_{i=0}^{n} F_n (iT, iT + \tau) + \text{sign}[\dot{z} - \dot{x}(\tau, T)] F_{df}$$

where m_p is the mass of moving parts of the rotor; z and x are the displacements of the rotor and friction shoe; F_n is the normal component of the force of pressing the friction shoe against the rotor; F_{df} is dry friction of the rotor; $T = f^{-1}$ is the pulse recurrence rate; τ is pulse duration.

The impulse of the force $\int_{iT}^{iT+\tau} F_n (\tau, T) dt = Q$ in our case is constant. Considering that the loaded rotor has some inertia, and the pulse recurrence rate, as already mentioned, is tens of kilohertz, the acceleration process can be represented as a continuous process where the rotor is simultaneously subjected to the constant force $F_{p0} = k_0 F_n^*$ and the random force $F_{pc} = k_c F_n^*$, where $F_n^* = QT^{-1}$ is the average value of the force of friction over one period T. With consideration of what has been said, displacement of the rotor during acceleration will be characterized by two parameters: the law of change in mathematical expectation $z_0 = 0.5 \cdot m_p^{-1} (F_0 - F_{df}) t^2$, and the law of change in variance $N_k m_p^{-2} (F_n^*)^2 \frac{t^3}{3}$. When the supply voltages are cut off (due to the high Q of the piezoelectric crystal plate), the oscillations damp out slowly. Clearly, during the braking period it would be preferable to keep the friction shoe in constant contact with the rotor. To do this, the friction shoe is pressed continuously against the rotor during braking by the force F_{ee} of the elastic element. In this case, the magnitude of the braking force F_T is greater than in an opposition circuit. Therefore the acceleration process should be realized when the piezoelectric motor is used in the braking mode, where longitudinal and flexural oscillations are damped. In the braking mode, force F_T can also be represented in the form of two terms: deterministic force $F_{T0} = k_0 F_{ee}$ and random force F_{TC} in the form of white noise of intensity $N_k F_{ee}^2$. Rotor displacement in the deceleration process will also be characterized by two parameters: the law of change in mathematical expectation $z_0 (t \geqslant t_p) = z(t_p) + V(t_p)(t - t_p) - 0.5 m_p^{-1} \times (F_{T0} + F_{df})(t - t_p)^2$, and the law of change in variance $N_k m_p^{-2} F_{ee}^2 \frac{(t - t_p)^3}{3}$, where t_p is the time of completion of acceleration (found from solution of the speed-optimum problem), $V(t_p)$ is the speed of the rotor at the instant of completion of acceleration, $z(t_p)$ is the position of the rotor at the instant of completion of acceleration. The expressions derived above are valid for the acceleration stage provided that $V(t_p)$ is less than the steady-state velocity, which should also be the goal in developing piezoelectric motors for the start-stop working mode.

The simplest mechanical model of longitudinal motion of the friction shoe can be represented in the form of a mass m_n that is comprised of the sum of the masses of the friction shoe and piezoelectric crystal plate; elements corresponding to the coefficient of losses to internal friction β and the coefficient of elasticity c of the piezoelectric crystal plate. A block diagram corresponding to controls



of the motion of the friction shoe is shown in the figure. In the acceleration process, a voltage $U_r = U_m \sin 2\pi ft$ is sent that excites longitudinal oscillations of the piezoelectric crystal plate together with the friction shoe. This state corresponds to position 1 of switches I. The perturbation in the given case is the pulse action by dry friction $F^*(\tau,T) = (k_0 + k_c)F_n(\tau,T)$. Auxiliary electrodes on the piezoelectric crystal plate provide the capability for measuring the quantity ε. If control U_{oc} related to the quantity ε by the operator W_{oc} $(p = d/dt)$ is introduced beginning at time t_p, the damping parameter can be made whatever is technically feasible. The control-displacement transfer function of the friction shoe (without consideration of hysteresis) takes the form

$$W(s) = \frac{X(s)}{U(s)} \frac{kc^{-1}}{[1 + W_{oc}(s)]\left(\frac{m_n}{c}s^2 + \frac{\beta}{c}s\right) + 1},$$

where U(s) is the Laplace transform of the control voltage normalized to the electrodes of the piezoelectric crystal plate, k is a linearized coefficient of proportionality.

If we disregard the dynamic properties of the amplification and measurement channel and consider $W_{oc}(p)$ as a feedback coefficient k_{oc}, the damping parameter can be determined from the expression

$$\gamma_{oc} = \sqrt{1 + k_{oc}} \cdot \gamma,$$

where $\gamma = 0.5\beta(m_n c)^{-0.5}$ is the damping parameter in a system without feedback. Shunting of the electrodes to which the excitation voltage U_r has been applied is equivalent to the earlier introduced U_{oc}. In this case, $k_{oc} \to \infty$ corresponds to $R_{sh} \to 0$, where R_{sh} is the shunting resistance. This explains the deficiency of such damping, since in case of necessity the source of the auxiliary controlling signal must have exaggerated power. After completion of the braking process, the masses of the piezoelectric crystal plate with friction shoe and of the rotor are joined (switches II are set in position 2). The control-displacement transfer function of the rotor is determined by W(s) with substitution of the sum $m_n + m_p$ in place of m_n, and the expression for the damping parameter takes the form

$$\gamma^*_{oc} = 0{,}5\beta \sqrt{1 + k_{oc}}\,[(m_n + m_p)c]^{-0{,}5}.$$

When conditions $k_{oc} \gg 1$ and $m_p \gg m_n$ are met, we can write the approximation

$$\gamma^*_{oc} \approx \sqrt{k_{oc} \cdot k_m^{-1}}\,\gamma,$$

where $k_m = m_p m_n^{-1}$. We can see from the last expression that the increase in mass after completion of braking reduces the damping parameter, but in this case the dry friction of the rotor F_{df} is "connected up" as a damping force, which has a detrimental effect on static accuracy, without any reduction in the natural frequency. After completion of braking, the error of displacement of the rotor to the predetermined position can be reduced or eliminated by control signal U_y. In this regard, it is necessary that there be no slipping of the friction shoe relative to the rotor $F < F_{T0} - n\sigma F_{ee}$, where $F = k\varepsilon$, $n = 2.7$-3 corresponds to probability of 99.3-99.7% that F_{TC} will not go beyond the limits $\pm n\sigma F_{ee}$. On the diagram $T = RC_n$, where R is the internal resistance of source U_y, C_n is the capacitance of the piezoelectric crystal plate. The double switch on the part of the diagram corresponding to the transfer function $U(s)U_y^{-1}(s) = (TS + 1)^{-1}$ reflects the capacity of the piezoelectric crystal plate to remember the applied voltage when the electric circuit is broken.

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CSO: 8144/1365

UDC 62-50

DECOMPOSITION IN CONTROLLED DYNAMIC SYSTEMS

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 17, No 7 Jul 81 (manuscript received 13 Nov 78) pp 120-126

TSURKOV, V. I., Computer Center, USSR Academy of Sciences, Moscow

[Abstract] The decomposition method is proposed for optimal control in multidimensional systems. It involves the introduction of macrovariables with extraction of bonds corresponding to the subsystems, and it features general constraints. Specifically a simple system consisting of two harmonic oscillators is considered. The optimization problem is first solved directly by application of Pontryagin's principle of the maximum to the Hamiltonian with coupled variables which satisfy the corresponding differential equations and boundary conditions, which leads to independent equations for local control optimization. The problem is then solved by the decomposition method, after aggregation through a change of the variables to corresponding macrovariables with normalized weighting factors, which leads to a simple relation for the coupled functions. Subsequent integration and substitution yields the optimum controls in local problems. This method is much easier than direct solution, especially when the number of elements in the system becomes larger. References 8 Russian.
[201-2415]

UDC 621.855.001.24

REDUCING NOISE IN CHAIN TRANSMISSIONS

Moscow VESTNIK MASHINOSTROYENIYA in Russian No 6, Jun 81 pp 29-31

FOT, A. P., engineer, and UCHAYEV, P. N., candidate of technical sciences

[Abstract] Reduction of noise in chain transmissions was studied experimentally with special noise measuring equipment in a chamber, to determine the feasibility of higher operating speeds. Both open and enclosed horizontal transmissions were tested, transmitting a power of 10 kW, PR and 2PR roller chains as well as type-3 tooth chains with pitches t = 12.7-25.4 mm. The distance between shafts

was varied from 20t to 40t, the speed of the drive shaft was varied from 500 to 800 rpm, and the transmission ratio was varied from 0.5 to 2. The resultant octave-band spectra of sound pressure indicate that noise is most effectively reduced by replacement of single-row roller chains with multirow ones and further by replacement of roller chains with tooth chains. Sprocket wheels with 19-50 teeth having an involute profile should yield excellent results. No advantage of textolite over steel as the material of sprocket wheels has been noted, the light weight of textolite evidently offsetting its damping characteristics. Thus special damping sprocket wheels, also hermetic covers for operation in an oil bath, are recommended. Figures 4, references 8: 6 Russian, 2 Western.
[193-2415]

UDC 621.822.2

CHARACTERISTICS OF HYDRODYNAMIC JOURNAL BEARINGS WITH SPIRAL GROOVES IN COAXIAL ALIGNMENT OF SHAFT AND BUSHING

Moscow MASHINOVEDENIYE in Russian No 3, May-Jun 81 (manuscript received 6 May 80, after completion 9 Jan 81) pp 109-113

YAVELOV, I. S., Moscow

[Abstract] Helical grooves in hydrodynamic bearings contribute to higher pressure in the lubricant film and thus to more stable rotation, but they also reduce the load capacity. Here the characteristics of such bearings are analyzed which determine the flow rate of lubricant and thus the bearing temperatures as well as the pressure rise in the lubricant film. The calculations are based on the equation of a screw pump and the condition of continuity, with the pressure above the groove zone assumed to decrease linearly from maximum to zero. Such calculations have been made in dimensionless coordinates, with the aid of a digital computer, and the results are now compared with experimental data. Within the practical range of parameter values, a relative groove depth of 0.1-0.2 and a relative groove pitch of 0.6-0.8 will ensure the maximum flow rate and pressure. The flow rate through a bearing with helical grooves is, furthermore, found to be several times higher than through a light-load bearing of a similar geometry but without grooves. Figures 4, references 5: 4 Russian, 1 Western.
[199-2415]

UDC 532.516

CALCULATING LOAD CAPACITY OF RADIAL GAS BEARINGS WITH DISCRETE GAS BLASTING

Moscow MASHINOVEDENIYE in Russian No 3, May-Jun 81 (manuscript received 21 Apr 80) pp 92-97

GRUDSKAYA, Ye. G. and KARPOV, V. S., Leningrad

[Abstract] Gas bearings with gas blasting through an array of holes uniformly distributed in two planes symmetric with respect to the center plane combine

a simple construction and a high load capacity. Here, for calculating the pressure in the lubricant film and the load capacity of such a bearing, the Reynolds nonlinear partial differential equation for a multiply-connected region is solved numerically by a net-point method, without any special assumptions. The results of this approximate calculation are found to agree closely with experimental data for such bearings with n = 3 or 6 holes per plane, over the entire range of blast pressures, as long as the eccentricity is not too large. There is some discrepancy when the eccentricity exceeds 0.6, probably due to inertia effects resulting from a higher gas velocity at the entrance to the lubricant film as well as due to calculation errors. The discreteness of blasting influences the load capacity less as the shaft speed increases. Figures 4, tables 2, references 8: 6 Russian, 2 Western.
[199-2415]

UDC 621-503.52

SYNTHESIZING CONTROL FOR PROGRAMMED MOTION OF AUTOMATIC MANIPULATORS

Moscow MASHINOVEDENIYE in Russian No 3, May-Jun 81 (manuscript received 25 Jul 79, after completion 28 Jan 81) pp 50-54

VUKOBRATOVICH, M. and STOKICH, D., Belgrade, Yugoslavia

[Abstract] An algorithm has been constructed for controlling the first-level (unperturbed) motion of an automatic manipulator from a given initial state to a given final state. The control function is sought which will ensure that the nominal trajectory will be followed at a preset velocity. For this purpose, the automatic manipulator is divided into two functional subsystems independently performing their tasks: positioning and orientating. A control is synthesized for the programmed motion of each, taking into account the respective numbers of degrees of freedom. The procedure is demonstrated on the synthesis of the reference trajector and the programmed control for a specific manipulator consisting of tongs hinged through an intermediate member to a drive set of electric motors. Figures 3, references 7: 3 Russian, 4 Western.
[199-2415]

UDC 621.9.077-52

METHODS OF CONTROLLING MOVEMENT OF AUTOMATIC MANIPULATOR ELEMENTS

Moscow STANKI I INSTRUMENT in Russian No 4, Apr 81 pp 8-10

KNYSH, P. I.

[Abstract] An analysis is made of the method of passive control of automatic manipulators, when lightweight braking devices are installed in the joints of the arm which make it possible to control the motion transmitted to elements

from drives installed on the base of the manipulator. The controlled brake creates a counteracting force, and therefore this method of control is called "control by counteraction." In drive systems utilizing this type of control the motor is placed on the base and a kinematic chain transmits motion to the controlled element. The braking device responds to a signal from a program unit and creates a counteracting torque that balances the motor torque. The required movement of the controlled element is made possible by a specific change in the counteracting torque with a practically constant driving torque. Movement of the controlled element to its return position is accomplished by reversing the motor upon an instruction from the program unit or control system. This system makes it possible to create automatic manipulators with a random number of degrees of mobility, whereby all motors can be placed on the base and lightweight braking devices installed in individual joints can ensure the desired pattern of movement of controlled elements. The operation of a controlled throttling valve is discussed, which offers the advantages of a hydraulic drive along with those of control by counteraction. An electrically controlled throttling valve is considered especially advantageous. A comparison is made between drive systems with control by counteraction and drive systems with direct control. The distinctive features of and requirements for the former are discussed in detail. Emphasis is placed on the design characteristics of controlled throttling valves, which should have minimal internal leaks and practically complete lack of leaks of fluid to the outside. The general conclusion is drawn that the use of drive systems with control by counteraction in automatic manipulators makes it possible to improve their functional capabilities, their accuracy, stability and safety while reducing the weight of moving parts. Figures 5.
[200-8831]

UDC [621.9.06-52:658.527].001.57:681.3

INVESTIGATING PRODUCTIVITY OF AUTOMATIC LINES BY COMPUTER SIMULATION

Moscow STANKI I INSTRUMENT in Russian No 4, Apr 81 pp 5-7

KOROVYANSKAYA, Ye. I., MESHKOVA, M. M. and CHERPAKOV, B. I.

[Abstract] A description is given of studies conducted at the Experimental Scientific Research Institute of Metal-Cutting Machine Tools on the application of the method of simulation on a computer for studying the influence of various factors on the productivity of automatic lines. Factors studied include the reliability of equipment, the number of attending personnel and the amount of maintenance equipment. A statistical model of an automatic line has been developed on the basis of the GPSS/360 simulation system. This model is distinguished by the fact that it can take into account both accidental failures of equipment and individual components including cutting tools, and routine maintenance. The model of the functioning and operation of an automatic line is in the form of a one-dimensional chain with interleaving links. The links are of two kinds: sections of the line and containers for storing intermediate products. Each pair of links comprises a conventional element and all elements are numbered in order.

The totality of all the transport equipment and containers of a single element is designated as a standard accumulator. In the model studied the line is assumed to be a flexible line, in terms of the connection of equipment to it. Several sections performing identical operations in parallel can operate independently. The first accumulator has a unlimited amount of stock and the output accumulator (store) represents a storage area of unlimited capacity for receiving finished products. If there is no stock in the accumulator immediately preceding a line section, then this section stops when treatment of the last part has been completed. A line section stops upon completion of treatment of a part if the accumulator next in line is overfilled. The functioning of the automatic line is thought of as the interaction of a series of regulated and unregulated flows. One flow, for example, represents the flow of stock entering the automatic line and others represent accidental failures of a component. The separate origin of failures of equipment and tools can be simulated in the model. The line is attended by a crew of adjusters and repairmen who eliminate sudden failures of equipment and perform routine maintenance. The model also simulates the division of labor among maintenance personnel. An analysis is made of the accuracy of simulation results based on the method of statistical tests. Experiments have demonstrated that the productivity, equipment utilization factor and other characteristics of automatic lines vary within the range of ±2.5 to 3 percent from the mathematical expectation when the duration of simulation is extended. The equipment utilization factor is considered the main characteristic of an automatic line. Precise estimation of this factor is discussed in detail. A series of simulation experiments was carried out to determine the dependence of the productivity of an automatic line on operating conditions. The results indicated a continuous period of operation of not less than 30 h after the establishment of steady conditions. It has been demonstrated that for a correct estimate of the statistical characteristics of an automatic line it is necessary to include a block in the computer program that automatically determines the instant that the process reaches steady-state conditions. Simulation results demonstrated that increasing the number of maintenance personnel for an automatic line produces an increase in productivity only to a certain limit, after which such an increase in number is ineffective. The equipment utilization factor can be increased only by introducing measures conducive to improvement of the reliability of equipment and tools and to reducing equipment maintenance time. Figures 4, references 4 Russian.
[200-8831]

UDC 621.007.52

NEW ELASTIC ROBOT MANIPULATOR GRIPS

Moscow VESTNIK MASHINOSTROYENIYA in Russian No 7, Jul 81 pp 10-11

PEROVSKIY, A. P., candidate of technical sciences, and PEROVSKIY, S. A., engineer

[Abstract] The principle of action and design of grips which are highly adaptable to the shape of the gripped objects have been described: these grips are fitted with rubber balloons filled with a friable medium and operate with power-driven

metal levers. Operating experience has shown them to be imperfect. New grips have been designed which eliminate these shortcomings by replacing the rigid lever system with a rubber balloon with a hoof-shaped cross section. These grips require a compressed air source and a vacuum device. These new grips are designated VUZ-U. These grips are exceptionally simple to construct and operate without adjustment to grip man-made objects of any shape, made of metal, wood, plastic and glass in any sequence. Figure 1.
[192-8617]

UDC 62-85.007.52

CALCULATING COORDINATE OF ONSET OF PNEUMATIC DRIVE PISTON BRAKING IN INDUSTRIAL ROBOT

Moscow VESTNIK MASHINOSTROYENIYA in Russian No 7, Jul 81 pp 7-10

PAROY, A. A., candidate of technical sciences

[Abstract] Pneumatic drives are employed in industrial robots with cyclic control and hoisting capacities of up to 20 or 30 kilograms. These drives are usually fitted with braking devices, but insufficient attention has been given to calculating their braking parameters, a major one of which is the coordinate of pneumatic drive piston position at the start of the braking process. Approximate formulas are proposed for various piston movement conditions up to and including braking, assuming that air temperature and pressure in the main pressure line are constant. The correct choice of the braking path length is important in designing braking devices; therefore the determination of the coordinate of the onset of the braking process enables designers and planners to resolve this critical problem. Figures 2, references 3 Russian.
[192-8617]

UDC 62-522.007.52

DETERMINING MAXIMUM VELOCITY TRAJECTORIES OF CYCLE TRAVEL OF HYDRAULICALLY ACTUATED ROBOT ARM

Moscow VESTNIK MASHINOSTROYENIYA in Russian No 7, Jun 81 pp 3-5

SEMENOV, Ye. I., doctor of technical sciences, and SULEYMANOV, B., engineer

[Abstract] A major task in designing robots for the forging and pressing industry is to develop programs for time measurement analysis to optimize the work of these manipulators. Linear and angular velocities depend on reduced mass, moment of inertia and accelerations. Intermediate robot arm positions do not have critical position requirements imposed on them, but when the arm is coming to a halt in operating position, the braking device must absorb sufficient kinetic energy to prevent impact loading at the end point. We must know the nominal data of a robot to calculate its optimum trajectories: maximum velocity, maximum angular momentum, radius, loaded weight and angle of rotation. Polar coordinate

graphs are provided to illustrate the distribution of forces during operation and braking. Figures 4, references 5 Russian.
[192-8617]

UDC 621.73.077-52:62-523.3

ELECTROHYDRAULIC DRIVE FOR ROTATING TOOL HOLDER OF FORGING MANIPULATOR

Moscow VESTNIK MASHINOSTROYENIYA in Russian No 7, Jul 81 pp 5-7

NEKHODA, V. G. and MOROZOV, V. Ya., engineers

[Abstract] Forging of heavy billets can be automated with forging units consisting of a press, manipulator arm and programmable digital control unit. The critical parameters include high speed, accurate positioning and wide range of velocity control. A hydraulic system for a forging manipulator drive is presented which has a maximum fluid flow rate of 180 liters per minute and nominal pressure of 16 MPa. The hydraulic pump used in this device is the axial-piston pump RNAS-125/320. A three-position hydraulic distributor R322-AL44-RA22050 and electrohydraulic booster UE85-32/200 are used to start and stop the drive. A M-KP32-01 safety valve limits pressure and an AR-L6.3/32 storage tank eliminates pressure surges that the safety valve cannot handle. An oscillogram is provided to illustrate the braking process and the dynamics of the various parameters during braking. The drive structure discussed guarantees the required manipulator parameters and may be used to develop rotary tool holder drives and moving carriages for many forging manipulators with capacities over 2.5 tons. Figures 6, reference 1 Russian.
[192-8617]

UDC 621.001

ACTIVE DAMPING OF MECHANICAL SYSTEMS

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian No 4, Apr 81 (manuscript received 17 May 79) pp 17-22

BURLAYEV, V. I., candidate of technical sciences

[Abstract] The author considers a class of mechanical systems operating in a cyclic mode with execution of the task in the first part of the cycle, and return of the system to the initial state in the second part of the cycle. At the instant of completion of the first (working) part of the cycle, the system is subjected to perturbations characterized in the general case by n-dimensional vectors of displacement and velocity for a system with n degrees of freedom. During the second part of the cycle, the system is acted on by a certain control function that moves the system from the point in phase space characterized by the perturbation vectors to the coordinate origin. An analysis is made of this second part of the cycle, and the minimum range of variation of the control function is determined. The solution is given in dimensionless form. The proposed method is compared with solution of the optimum control problem by using Pontryagin's maximum principle. Figures 2, references 4 Russian. [177-6610]

UDC 628.517.4

OPTIMIZATION OF ACTIVE VIBROPROTECTION DEVICE

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian No 4, Apr 81 (manuscript received 18 Jun 79) pp 22-26

SEMENOV, Yu. A., candidate of technical sciences

[Abstract] One way to handle protection of hardware from external vibration is to develop an optimum vibroprotection system of active type when the structure of the passive part is predetermined--an elastic mechanical system with weak dissipation that eliminates the limiting case of rigid fastening of the equipment to its base. The author considers a mechanical system with one degree of freedom to which a controlling dynamic input is applied. The differential equation corresponding to the model is $m\ddot{q} + b\dot{q} + cq = f(t) + u(t)$, where q is the generatized coordinate of the system, m is mass, b is drag, c is stiffness, f(t) is the external force, and u(t) is the control. A solution is found for the problem of optimizing control u(t) on a given time segment. The criterion functional to be minimized is deviation of the perturbed motion from the programmed motion. An analysis is made of the problem of synthesizing an active vibroprotection system as an automatic control system with feedback that reduces to selection of a transfer function or frequency response of the controlling device that minimizes this functional transformed by the Parseval formula. The vibroprotection system is taken as asymptotically stable. Based on solution of the problem of optimum synthesis, an active pneumatic vibration damper has been designed and put into production. Comparative analysis of the dynamic characteristics of the optimum and uncorrected systems has shown that introducing an optimum control law reduces the maximum coefficient of dynamicity by a factor of three while cutting the frequency limit in half. Figures 2, references 3 Russian. [177-6610]

UDC 62-229.72

INDUSTRIAL MINIROBOTS OF MODULAR DESIGN WITH DISCRETE PNEUMATIC DRIVE

Moscow PRIBORY I SISTEMY UPRAVLENIYA in Russian No 6, Jun 81 pp 22-23

KROLIK, D. L., KHANUKAYEV, S. T., KURMAN, E. A., ONISHCHENKO, E. A., ABITOV, A. D. and POYDA, M. N., engineers

[Abstract] The article describes five modules used in minirobots: a two-limit module, a multiple-limit module, and modules for lifting, rotating and transverse

displacement of items with mass of up to 0.5 kg. Appropriate combinations of these modules can provide intermediate positioning or positioning with respect to two end points. The accuracy of location in either case is within ± 0.05 mm. Each module is an independent functional unit with its own pneumatic drive operating on compressed air at a pressure of at least 0.35 MPa. A table is given summarizing the parameters of four robots that utilize these modules: PMR-0.5-254PV, PMR-0.5-200K, PMR-0.5-254KS and PMR-0.2-126PV. These robots operate in cylindrical and cartesian coordinate systems and have an arm travel of 254 mm with discreteness of 2 mm. Figures 3, table 1.
[191-6610]

UDC 621.7.077.62-85

MANIPULATOR WITH PNEUMOACOUSTIC OUTSIDE INFORMATION PICKUP

Moscow PRIBORY I SISTEMY UPRAVLENIYA in Russian No 6, Jun 81 pp 24-25

SHEL'PYAKOV, A. N., engineer, and ISUPOV, G. P., candidate of technical sciences

[Abstract] The paper describes a very simple manipulator with pneuomacoustic locator that can handle items regardless of position within the limits of the manipulator arm. The manipulator consists of a pneumodrive carrying a Hartmann oscillator and a receiver that acts on the principle of disruption of a laminar jet by ultrasonic waves. The change in pressure at the output of this acoustic-pneumatic receiver reaches 2 kPa. The output signal is sent through a fluidic element to amplifiers connected to two cavities of a pneumatic cylinder. The locator tracks the edge of an item in the form of a plate with an error of ±1.5 mm at a drive speed of 0.8 m/s from a distance of 200 mm. The manipulator can handle moving items if their velocity does not exceed that of the drive. Figures 3, references 2 Russian.
[191-6610]

UDC 621.7.077

USING INDUSTRIAL ROBOTS TO AUTOMATE MULTIPASS SHEET STAMPING

Moscow PRIBORY I SISTEMY UPRAVLENIYA in Russian No 6, Jun 81 pp 25-26

SEMENOV, Ye. I., doctor of technical sciences, SKORODUMOV, S. A., KRYUCHKOV, M. A. and SULEYMANOV, B.

[Abstract] The paper describes a multipass sheet stamping operation that uses industrial robots to fabricate the reflector housing of a light fixture on a railway car. The robot complex was developed at the All-Union Machine-Building Correspondence Institute (Moscow) and contains a double-action press, a sheet feeder, a single-crank press, a stacker and two industrial robots. The sequence

of operations is described in detail. All equipment in the complex is provided with interlock devices to prevent accidents and breakage. The complex is being successfully used at the Riga Car Construction Plant. Figure 1, references 3 Russian.
[191-6610]

UDC 621.317.729.2:62-229.72

PROBE MANIPULATORS FOR STUDYING SEMICONDUCTOR MATERIALS AND STRUCTURES ON PLATES

Moscow PRIBORY I SISTEMY UPRAVLENIYA in Russian No 6, Jun 81 pp 26-27

RACHKIN, V. N., GASILOV, E. G., KULAGIN, B. I. and GORBACHEVA, A. M., engineers

[Abstract] The article describes three probe manipulators developed at the Penza Affiliate of VNITIpribor: single-probe, two-probe and universal manipulators. These instruments can be used for checking charge carrier concentration in epitaxial layers, surface potential, surface state density, magnitude and stability of charge in a dielectric and on an interface and so on by the method of capacitance-voltage curves. Micrometer screws enable precision displacement of the probes in all three planes. Pressure of the probe point against the substrate is constant. Capacitance is kept low by reducing the mass of metal in the needle holder, and by using high-frequency connectors and cables. All manipulators are provided with tungsten probe tips, but other materials can be used for special applications. The probe manipulators can be connected to all types of measuring instruments without extensive modification. Figures 3.
[191-6610]

TURBINE AND ENGINE DESIGN

UDC 621.45:62-59

ANALYSIS AND IMPROVEMENT OF GAS EXHAUST PIPE WITH ELBOW FITTING FOR TURBOPROP ENGINES

Kazan' IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 81 (manuscript received 29 Jan 79) pp 94-95

ZAKHAROV, A. M., RAYKIN, L. I. and ZELENOV, S. N.

[Abstract] Space and weight limitations as well as various engineering constraints complicate the design of the gas exhaust pipe for turboprop engines. An experimental study was made to evaluate the losses in such a gas exhaust pipe with an elbow fitting. The aim was to determine the possibility of improving the gas dynamic characteristics of such an exhaust without modifying the overall configuration but by inserting a deflector into the elbow, to determine the change in the total-pressure field at the inlet caused by the elbow at the outlet, and to determine the thrust coefficient as well as the difference between the theoretical angle and the actual angle of the flow direction through the exhaust elbow with and without a deflector respectively. The best results were obtained with a deflector of 73% length relative to the elbow. Figures 2, references 3 Russian.
[197-2415]

UDC 534.14.621.454

EXCITATION OF SURGE-LIKE VIBRATIONS BY APERIODIC EXTERNAL ACTION

Kazan' IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 81 (manuscript received 15 Oct 79) pp 34-37

PIS'MENNYY, I. L.

[Abstract] The effect of surging the fuel supply, an aperiodic action, on vibrations in turbojet engines is analyzed on the basis of a simple model of a high-pressure compressor followed successively by an inertia (inductance representing an acoustic mass), a gas tank with a capacitance (acoustic compliance)

and a throttle with subsonic discharge (resistance). The amplitude- and phase-frequency characteristic of the resulting forced vibrations is calculated from the transfer function of the system with the aid of the first shifting theorem and the principle of harmonic balance through hodographs in the complex plane. The pressure is assumed to decrease exponentially after the surge, while the temperature does not rise. Just as after throttling, also an aperiodic action, the frequency of vibrations is found to first increase sharply, but not so high, and then decrease smoothly. Figures 2, references 2 Russian.
[197-2415]

UDC 621.438:621-712

THERMODYNAMIC ANALYSIS FOR COMPARING EFFICIENCIES OF SEMICLOSED AND OPEN AIR COOLING SYSTEMS FOR GAS TURBINE ENGINES

Kazan' IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 81 (manuscript received 29 Feb 78), pp 18-23

MANUSHIN, E. A.

[Abstract] Semiclosed and open air cooling systems for gas turbine engines are compared with respect to efficiency on the basis of a thermodynamic analysis. First the compressor parameters are calculated, then the specific work of the turbine. With the air exhausting behind the compressor, the parameters of the latter remain the same with an open cooling system as without cooling but become different with a semiclosed cooling system. Air leakage at the inlets to hot engine components is usually disregarded in calculations, but it contributes to losses and lowering of the efficiency. Actual calculations made for gas temperatures from 1370 to 1870 K with a variable compression ratio reveal that a semiclosed air cooling system is more efficient than an open one over the entire range of this ratio. Figures 3, references 7 Russian.
[197-2415]

UDC 621.438

DISTINGUISHING DESIGN FEATURES OF HYDROGEN-VAPOR PROPULSION TURBINES

Kazan' IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 81 (manuscript received 26 Dec 79) pp 13-18

BYKOV, N. N. and CHEKALOV, M. A.

[Abstract] The design of a hydrogen-vapor propulsion turbine is analyzed on the basis of the equation of power balance and the velocity vector triangle, with emphasis on features which distinguish it from that of a conventional gas turbine. The differences derive essentially from the differences between the physical properties of hydrogen and those of conventional gas, also from the

fact that the pressure before a hydrogen-vapor turbine is produced by a pump rather than the compressor. This separation of turbine and compressor channels makes it possible to raise the pressure before the turbine so as to ensure the necessary expansion ratio in the latter, while limiting, however, the compression ratio in the compressor. The analysis reveals that the turbine parameters depend appreciably on the compressor performance. The calculation of load factors indicates that it is possible to reduce the number of turbine stages by increasing the load per stage. Figures 4, table 1, references 2 Russian.
[197-2415]

UDC 621.436.001.57

GENERAL APPROACH TO OPTIMIZING DIESEL ENGINE BASED ON ITS MATHEMATICAL MODEL

Leningrad DVIGATELESTROYENIYE in Russian No 3, Mar 81 (manuscript received 24 Sep 80) pp 8-10

ZHMUDYAK, L. M., candidate of technical sciences, API imeni I. I. Polzunov [expansion not given]

[Abstract] A general stepwise procedure for technoeconomic optimization of a Diesel engine based on its mathematical model is described which takes into consideration the interlinkage between subsystem and system optimization. The working cycle must be treated in the first few steps of the optimization process. The procedure is designed for ultimate optimization of as large as possible systems. The criterion functional and the constraints are established for each selected subsystem, taking into account all parameters which link it to other subsystems. Among possible ways to incorporate the constraints in the criterion functional are consideration of a system more general than the engine alone (e.g., the entire transportation system) or consideration of the system from many standpoints, engineering as well as economic. It is also necessary to select a rational sequence of optimization steps, the most general variant of such a sequence being optimization of the entire system at once. Other variants are simultaneous optimization of the subsystems, each optimized sequentially, or optimization of the subsystem most nearly reflecting the characteristics of the system and then attaching to it the other subsystems in a continuing optimization process. The choice of sequence will depend not only on the characteristics of the system but also on the application and on management factors. References 4 Russian.
[189-2415]

UDC 621.41.001.5

COMPLEX STUDIES OF INNER LOOP OF ENGINE WITH CLOSED REGENERATIVE CYCLE

Leningrad DVIGATELESTROYENIYE in Russian No 3, Mar 81 (manuscript received 9 Jun 80) pp 3-6

DOBROSOTSKIY, A. V., candidate of technical sciences and BOYKO, S. V., engineer

[Abstract] A procedure has been developed for complex studies of the inner loop in Stirling, Brayton, Ericcson and other engines, where the exergetic method of thermodynamic analysis and the principle of integrity are applied to the closed regenerative cycle as a complex object. According to the structural model of such a study, the inner loop can be treated separately from the entire cycle when it is deterministically coupled to the heat source, an infinite-capacity energy receiver and a load receiver. The study involves acquisition of preliminary data from various primary sources, their statistical processing, and evaluation of the results. It also includes thermodynamic analysis and appropriate correction of the structure on the basis of feedback control. Instantaneous or integral values of two thermal (caloric) parameters and the mass of the working substance serve as primary-data signals. The output is an exergetic diagram, one for a Stirling engine shown here as an example. On the basis of the first two laws of thermodynamics, it is then possible to proceed to a differential analysis of individual cycle components under real operating conditions. Figures 3, table 1, references 3 Russian.
[189-2415]

UDC 621.43.038.001.5:621.43-43

OPTIMIZING ANGLE OF INJECTION ONSET IN DIESEL ENGINES

Leningrad DVIGATELESTROYENIYE in Russian No 2, Feb 81 (manuscript received 19 Jul 80) pp 16-18

FAYNLEYB, B. N., doctor of technical sciences, GINZBURG, A. M., candidate of technical sciences, and VOLKOV, V. I., engineer, TsNITA [expansion not given]

[Abstract] Fuel injection angle in a diesel engine must be advanced in direct proportion to the rate of rotation of the gear shaft. But when the injection angle is advanced and the shaft rpm drops, combustion starts too early and the engine "diesels": rigidity increases, combustion pressure reaches the maximum level, and exhaust gas becomes toxic. A special injection angle advancer was used to maintain optimum angle under partial frequency conditions. Such devices include centrifugal clutches and clutches with hydraulic boosters. Tests were conducted on the D-144 and SMD-60 diesel engines. Dynamic indicators--rigidity and maximum pressure--remain equivalent to indicators obtained with serially manufactured pumps at optimum angles of injection advance. Figures 3.
[190-8617]

UDC 621.432.9.001:621.43.018.3

ENHANCING ECONOMY OF COMBINED MOTORS AND POWER TURBINES

Leningrad DVIGATELESTROYENIYE in Russian No 2, Feb 81 (manuscript received 15 Aug 80) pp 6-7

KHUTSIYEV, A. I., candidate of technical sciences, ULANOVSKIY, E. A. and YEVSTIFEYEV, B. V., engineers, Kolomna Affiliate, VZPI [expansion not given]

[Abstract] In combined engines having a second stage gas turbine which transmits power to the gear shaft, energy utilization of exhaust gases is improved. Industrial manufacture of combined engines with power turbines is being held up due to increased thermal stress and the additional reducing gear required between the turbine and the engine gear shaft. This reduces reliability of the power train. To optimize the phases of gas distribution, additional improvement must be made in gas exchange and reduction of fuel consumption. The use of a combustion chamber blow-out by cylinder charge, with simultaneous enhancement to supercharge air pressure will reduce specific fuel consumption. Figures 2.
[190-8617]

UDC 62-755

USING BALLS FOR AUTOMATIC ELIMINATION OF DYNAMIC ROTOR IMBALANCE

Moscow VESTNIK MASHINOSTROYENIYA in Russian No 5, May 81 pp 50-51

NESTERENKO, V. P., candidate of technical sciences, and SOKOLOV, A. P., engineer

[Abstract] The use of rotors requires the elimination of both static imbalance and dynamic imbalance. The experimental device is a d.c. motor mounted on a base with flexible couplings, with a rotor consisting of a flywheel which has two annular grooves covered by rings, and two openings in the rings through which the balls are inserted into the annular cavities. Results show that the use of the circulating ball balancing system automatically corrects for rotor balance on a continuous basis and may be used in electrical equipment weighing 3-1000 kg with speeds of up to 600 radians per second. Figures 2, references 2 Russian.
[194-8617]

UDC 621.515

EFFECTIVENESS OF USING COMPRESSOR GUIDE VANES WITH CANTILEVER BLADES

Kazan' IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 81 (manuscript received 5 Dec 79) pp 72-74

ANYUTIN, A. N., BREKHOV, A. F., BUSLIK, L. N., GIRICH, G. A., YERSHOV, V. N. and REZNIK, B. G.

[Abstract] A design version of guide vanes for an axial compressor stage with cantilever blades was considered to determine the efficiency of this configuration. Aerodynamic tests of the sixth compressor stage of an aviation gas turbine engine were conducted to test the hypothesis that the intensity of the total secondary flows is minimum and that energy losses due to these flows can be considered minimum. The total pressure recovery coefficient in the guide vanes was calculated on the basis of flow parameters averaged over the radius and pitch of the guide vane cascade. The total pressure losses due to profile drag and secondary flows on the periphery of the cascade were not taken into account by the calulated values of the total pressure recovery coefficient. The hypothesis was confirmed by the experimental data. Figures 2, references 2 Russian.
[188-A-6521]

UDC 621.515.154:533.6.011

VARIATION OF STATIC PRESSURE AT REVOLVING BLADES OF AXIAL-FLOW COMPRESSOR DURING SURGING

Kazan' IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 81 (manuscript received 22 Feb 80) pp 62-66

SHATALOV, I. K.

[Abstract] An experimental study of surging in an axial-flow compressor was made, to determine the variation of the static pressure at swivel blades during such a period. Measurements were made at the Turbomachinery Laboratory of the Virginia Polytechnic Institute with Scanivalve Co. instruments. The static pressure as well as the total pressure and the velocity head were measured. An analysis of the respective oscillograms and profile curves reveals that during surging the static pressure fluctuates most widely at the convex surface at the entrance edge of a moving blade. The peripheral zone of a moving blade appears to be under the heaviest dynamic load then. Figures 4, references 3: 1 Russian, 2 Western.
[197-2415]

UDC 534.282:621.165

DAMPING TANGENTIAL VIBRATIONS OF TURBINE BLADES BY USING SHROUDS WITH CORRUGATED BANDS

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian
No 4, Apr 81 (manuscript received 14 Jun 79) pp 83-86

KOCHETOV, G. M., candidate of technical sciences, docent, SIDOROV, A. A., candidate of technical sciences, docent, and IVANOV, N. B., engineer

[Abstract] A disadvantage of the band shrouding used to stiffen turbine blading is the low damping property of such banding. An improvement is considered in this paper in which the thick steel band fastened to the blade tips is replaced by two thin bands between which is a corrugated band of even thinner sheet steel. The stiffness of such shrouding can be varied without an appreciable change in mass by modifications in the height and thickness of the corrugated banding. The damping properties of this type of shroud were studied on a special stand. The results show that vibration energy is dissipated in this type of shroud with single and multiple corrugated bands better than in one-piece shrouds. Figures 3.
[177-6610]

UDC 531.383

TWO-STAGE AUTOMATIC GROUND GYROCOMPASS

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian
No 2, Feb 81 (manuscript received 21 Jan 80) pp 58-63

SHESTOV, S. A., Moscow Technical College imeni N. E. Bauman

[Abstract] A theoretical analysis is made of a two-stage automatic ground gyrocompass consisting of a rate gyroscope with electrical feedback which reacts to the horizontal component of the angular velocity of the rotation of the earth and which is installed on a platform so that its output axis is vertical, and of a servo system for controlling the platform in response to the rate gyro's signals. If the vector of the gyro's angular momentum is brought in position with the meridional plane, following of the platform ceases. This design is superior to other two-stage gyrocompasses in that its operation is automated and the servo system does not allow high-frequency disturbances to affect the indicator section. The gyrocompass's operation is discussed in a geographical system of coordinates and right-handed systems of coordinates for the platform, frame of the rate gyro and gyro casing of the gyrocompass, respectively. Equations of motion are derived for the gyrocompass and the motion of the platform is described by a nonlinear differential equation showing that its motion is influenced by disturbing effects caused by inertia and damping of the rate gyro assembly. An estimate is made of the accuracy of and maximum time required for determining the meridional plane. It is demonstrated that by proper selection of the system's parameters a gyrocompass of this sort can be created which can determine the meridional plane in no more than 2 to 3 min. Figures 3, references 2 Russian.
[202-8831]

UDC 531.383

CHOOSING OPTIMUM PARAMETERS OF CELESTIAL DIRECTION FINDER BY STANDARD PROGRAM

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian
Vol 24, No 1, Jan 81 (manuscript received 8 Aug 79) pp 57-63

SERGEYEV, M. A., YUSHCHENKO, V. I., LEVANENKO, V. A. and RYSAKOVA, T. N.,
Leningrad Institute of Precision Mechanics and Optics

[Abstract] A celestial navigation system has been developed at the Department of Airborne Control Instruments in which two directions to celestial bodies are used to determine the angular coordinates (roll, pitch and yaw) of a flight vehicle. These directions are utilized by a stellar coordinate plotter that includes two celestial direction finders in which the principal optical axes are held in the direction to the corresponding celestial bodies. Laboratory studies and utilization of the celestial navigation system on flightcraft have shown that errors of measurement of angular coordinates are determined mainly by the errors with which the directions toward the celestial bodies are maintained. This paper gives algorithms of a standard program and computer printout, and also a method of data processing enabling selection of optimum parameters of the celestial direction finder in a given range of variation, as well as determination of constraints on the principal perturbations required to keep the mean square error within a certain value. Figures 3, references 5 Russian.
[174-6610]

UDC 531.383

USING RECURRENT SEARCH EVALUATION FOR CORRECTING INERTIAL SYSTEMS WITH RESPECT TO RELIEF FIELD

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian
Vol 24, No 1, Jan 81 (manuscript received 6 Jun 79) pp 63-69

BELOGLAZOV, I. N. and YERMILOV, A. S.

[Abstract] Considerable research has been done on the feasibility of using relief maps for evaluating the horizontal coordinates of flightcraft. The vertical parameters of flight are usually determined by a vertical channel of the inertial guidance system. However, the instability of this channel necessitates special measures for correction with respect to the readings of absolute altitude indicators or vertical velocity indicators. A new approach to the problem is proposed in this paper by using recurrent search evaluation, enabling the use of relief maps for correcting the vertical channel with respect to readings of a radar altimeter alone. The analysis is based on a navigational complex that includes three inertial system channels that measure the translational and angular coordinates of the control object, and also a computer with the relief map recorded in the memory. The authors give the results of mathematical modeling of the proposed recurrent search algorithm. Figures 3, references 6 Russian.
[174-6610]

FLUID MECHANICS

UDC 621.822.05.001.24

CALCULATING FLOW OF LIQUID THROUGH PASSAGEWAYS IN RADIAL HYDROSTATIC BEARING BY FINITE ELEMENT METHOD

Kazan' IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian
No 1, Jan-Mar 81 (manuscript received 22 May 79) pp 109-111

BELOUSOV, A. I., GORYUNOV, L. V., KADYSHEV, V. G., LUR'YE, M. M. and TAKMOVTSEV, V. V.

[Abstract] The passageways for the liquid in a hydrostatic bearing have a very intricate configuration, but subdividing them into simpler axial and end passageways with independent flow in each leads to large calculation errors. Here a finite element method is proposed, and it is demonstrated on a radial hydrostatic bearing with an axisymmetric laminar flow of a liquid having constant density and viscosity. Accordingly, the Stokes equation of pressure with the appropriate boundary conditions is replaced with the equivalent problem of finding the function which will minimize the velocity functional and the latter problem is solved by triangulation. Calculations for an arbitrary triangular finite element yield results which have been found to agree closely with those obtained by the method of electrohydrodynamic analogy. Figures 2, references 3: 2 Russian, 1 Western.
[197-2415]

UDC 532.526.4

CRITERIA OF SEPARATION AND SUPPLEMENTARY EQUATION FOR THREE-DIMENSIONAL TURBULENT BOUNDARY LAYER AT REVOLVING BLADE

Kazan' IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian
No 1, Jan-Mar 81 (manuscript received 23 Jul 79) pp 44-48

UGRYUMOV, M. L.

[Abstract] An important factor in the design of compressors is the development of three-dimensional turbulent boundary layers at swivel blades. For the purpose of analysis, the known criterion of separation for a stationary three-dimensional

boundary layer in a moving stream is extended to one moving along a swivel blade. For subsequently determining the velocity profile in sections through such a boundary layer, a supplementary equation is derived for its form factor $H = \delta^{*}/\delta^{**}: \Delta H/H_0 = -19.23\,N_{Ny} + 0.5097$ $(N_{Ny} > 0.0265)$ and $\Delta H/H_0 = 0$ $(N_{Ny} \leq 0.0265)$. These relations fit experimental data. The author thanks V. G. Prokopovich for providing unpublished experimental data. Figures 3, references 6: 4 Russian, 2 Western.
[197-2415]

UDC 621.438-2.262:536.244

EXPERIMENTAL STUDY OF HEAT TRANSFER AT SURFACE OF MOVING TURBINE BLADES

Kazan' IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 81 (manuscript received 22 May 78) pp 37-41

POCHUYEV, V. P. and SHCHERBAKOV, V. F.

[Abstract] The heat transfer at the surface of moving blades was studied experimentally in a prototype gas turbine, with the temperature of gas behind the combustion chamber varied from 840 to 1200 K. Specifically two new cast blades were tested, both in the shape of a shallow shell segment with a 33.33 mm chord and a thickness varying from 0.7 to 2.1 mm along the profile. Their temperature was measured with an array of thermocouples in 19 locations, the thermal flux transferred to them from the hot gas was determined by the method of transients at a thin body. Measurements were made during heating with the speed increasing from 6400 to 8500 rpm and during cooling with the speed decreasing from 8500 to 6400 rpm. The results indicate that the heat transfer at a moving blade, under conditions corresponding to $N_{Re}\ 2\cdot10^{5}$, is characterized by a higher intensity than under static conditions. The heat transfer coefficient, both local and mean, does not differ significantly from that under conditions of soft streamlining. The data have been evaluated in terms of the dimensionless N_{Nu} and N_{Su} numbers. Figures 4, table 1, references 4 Russian.
[197-2415]

UDC 629.194.34.536.468

CALCULATING PARAMETERS OF COMBUSTION PROCESS IN REACTOR WITH COMPLETE MIXING

Kazan' IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 81 (manuscript received 1 Nov 79) pp 29-33

ONISHCHIK, I. I.

[Abstract] The parameters of the combustion process are calculated on the basis of theoretical and empirical relations for iso-octane in a reactor with complete mixing of fuel and air ($\alpha = 1$). First the temperature of the combustion products

is determined from the equation of heat balance with the aid of expressions for the dependence of the heat content on the temperature (quadratic) and on the fuel concentration (linear). Subsequently the chemical reaction rate is determined from the equation of oxygen mass balance, the latter depending on both temperature and pressure. The results are then extended to both rich mixtures ($\alpha < 1$) and lean mixtures ($\alpha > 1$), the temperature of the combustion products decreasing in both directions and the reaction rate constant decreasing with richer mixtures but remaining constant with leaner ones. The results agree closely with experimental data. Figures 4, table 1, references 4: 1 Russian, 3 Western.
[197-2415]

UDC 534.141.62-135

AERODYNAMIC DAMPING OF BLADE VIBRATIONS IN REACTION TURBINE STAGES

Minsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ENERGETIKA in Russian No 6, Jun 81 (manuscript received 28 Jul 80) pp 120-123

SIDOROV, A. A., candidate of technical sciences, lecturer, KOCHETOV, G. M., candidate of technical sciences, lecturer, POLNIKOVA, T. V., candidate of technical sciences, AVDEYEV, G. N., student and TIMOFEYEV, Ye. V., STUDENT, Kaluga Branch, Moscow Higher Technical School imeni N. E. Bauman

[Abstract] Aerodynamic damping of blade vibrations in a straight reaction stage was studied experimentally at the Strength Laboratory of the Moscow Higher Technical School imeni N. E. Bauman in Kaluga. The cascade in these tests simulated that of the last stage of a rather small condensation turbine with the profile parameters $\bar{t} = 0.68$ and $\gamma_b = 23^o$, the channels of the cascade tilted through $\Delta\beta = 80^o$. The tests were performed in a wind tunnel, with the center blade elastically suspended in the air stream at a zero angle of attack. Tangential vibrations of this blade were induced at audio feequencies up to 200 Hz by means of an electromagnet. The ratio of air density o_0 to blade material density corresponded to real conditions, the characteristic parameter o_0b^2/m (b = length of the blade chord, m - mass of the blade) being varied over the $(0.949-2.32)\cdot10^{-3}$ range. The experimental points fit on a straight line so that the aerodynamic damping coefficient $\delta = Ao_0b^2mk$ (here k is the Struhal number) with A = 6.4 for one vibrating blade. The factor A was found to be independent of the Struhal number, an evaluation of these and other test data indicating that the value of this factor A depends only on the blade profile and the tilt angle of the channels in the cascade. Figures 3, table 1, references 3 Russian.
[188-2415]

SOME PROBLEMS OF SOLID BODY PENETRATION INTO PONDERABLE FLUID

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: MEKHANIKA in Russian Vol 33, No 6, Nov-Dec 80 (manuscript received 22 Feb 80) pp 43-53

AVAGYAN, S. G., Institute of Mechanics, ArSSR Academy of Sciences

[Abstract] Problems of penetration of a thin cone into a compressible ponderable fluid are considered. The corresponding equation of axisymmetric flow and Bernoulli's equation are solved, the former by the method of sources with the aid of integral transformations, for a fluid with a free surface and for a fluid bounded by a thin elastic membrane. The velocity is assumed to remain constant during penetration, both subsonic and supersonic motion being considered. In the presence of gravity, the resistance of the fluid is found to increase in either case as the dimensionless parameter gt/V_0 (g - acceleration due to gravity, V_0 - velocity of penetration, t - time) increases. The author thanks A. G. Bagdoyev for guidence. Figures 2, references 4 Russian.
[191-2415]

UDC 532.531

EXPERIMENTAL STUDY OF PATTERN OF BOUNDARY FLOW IN STREAM WITH INITIAL TWIST

Kazan' IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 81 (manuscript received 18 May 79) pp 67-71

SHCHUKIN, V. K., KHALATOV, A. A., LETYAGIN, V. G. and KOZHEVNIKOV, A. V.

[Abstract] An experimental study was made of the boundary flow of an isothermal air stream along the wall of a cylindrical channel 80 mm in diameter and 150 diameters long, after the stream has been swirled at the channel entrance with a paddle wheel 3 mm in diameter. The velocity field in the initial zone was measured with a set of hot-wire anemometer instruments, including single-wire probes with straight gilded tungsten wires 6-8 μm in diameter and 1-2 mm long. The readings were calibrated against the profile of the axial velocity component in the zone of stabilized flow. An evaluation of the results has established that within the $N_{Re,d} = 4\cdot10^4-1.5\cdot10^5$ range of the Reynolds number the velocity profile follows the universal relation almost exactly. The results also establish a unique relation between the swirl parameter, whose characteristics have been found to be universal, and the exponents m and n of the power-law velocity profiles (resultant velocity and axial velocity respectively). On the basis of the 2-layer model of boundary flow, an equation is proposed for the relative thickness of the laminar sublayer in the profile of either the axial velocity or the resultant velocity. Initial swirl reduces thickness in both profiles. Figures 4, references 5 Russian.
[197-2415]

UDC 621.165

DEVELOPMENT AND EXPERIMENTAL STUDY OF NEW AERODYNAMICALLY IMPROVED SUBSONIC TURBINE BLADE PROFILES

Minsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ENERGETIKA in Russian No 4, Apr 81 (manuscript received 28 Feb 80) pp 48-53

BOYKO, A. V., FEDOROV, M. F., candddates of technical sciences, and KOZHEVNIKOV, S.N., engineer, Khar'kov "Order of Lenin" Polytechnical Institute

[Abstract] An investigation is made of the problem of automatic design of optimum turbine blade profiles. A method is outlined for putting together an algorithm for computer-programmed calculation of a profile with minimum aerodynamic losses in a turbo-machinery cascade with given geometric characteristics providing calculated flow parameters at the outlet and satisfying requirements of strength and technological feasibility. The coefficients of the polynomials that describe the convex and concave parts of the profile are deteriined by minimizing a criterion functional such as efficiency or the minimum of the maximum curvature of the outline of the profile. The proposed algorithm for analytical design of turbine profiles by means of power polynomials with respect to a geometric criterion of quality has been programmed in ALGOL-GDR and realized on a BESM-6 computer. Calculations show that 3-6 minutes of machine time is required to construct an optimum profile by power polynomials of fifth order. The gain in efficiency of the newly designed cascades as compared with existing versions over a wide range of inlet and outlet flow angles varies from 0.1 to 0.8%. Tests show that the new method of computer design is competitive with conventional techniques. Figures 3, references 5 Russian.
[178-6610]

UDC 539.529

MOTION OF FINELY DISPERSED INCLUSIONS IN VIBRATING VESSEL WITH LIQUID CONTAINING COMPRESSIBLE SPHERE

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 17, No 6, Jun 81 (manuscript received 20 Feb 80) pp 107-113

PUCHKA, G. N., Institute of Mechanics, UkSSR Academy of Sciences, Kiev

[Abstract] A theoretical analysis is made of vibrational displacement and vibrational stability of small gas bubbles and solid particles in the vicinity of a pulsating sphere located in a liquid that is contained in a vibrating vessel. In deriving the fundamental equations, it is assumed that the liquid containing the gas bubbles and the stationary pulsating sphere is enclosed in a rigid vessel vibrating in the longitudinal direction. The motion of the bubble mass is taken as constant at all times and the shape of the bubbles is assumed as always spherical. The radius of the sphere is much larger than that of a

bubble. It is further assumed that the walls of the vessel are sufficiently far from the sphere and bubbles that wall effect can be disregarded. Interaction between bubbles is also negligible. Standard solutions are given for the equations of motion of bubbles and solid particles. An analysis is made of the dynamics of small gas bubbles. References 5: 4 Russian, 1 Western. [190-6610]

MECHANICS OF SOLIDS

UDC 539.377

ASYMPTOTIC INTEGRATION OF THERMOELASTICITY EQUATIONS FOR CONICAL SHELL OF VARIABLE THICKNESS

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 17, No 4, Apr 81 (manuscript received 8 Jan 79) pp 118-122

MASLOV, N. M., Saratov State University

[Abstract] A conical shell of variable thickness is considered in an unsteady temperature field. Equations for the thermal field of the shell are derived by reducing the three-dimensional problem of heat conduction to a two-dimensional problem, assuming a linear law of temperature variation with respect to thickness. The behavior of the shell is determined by the variability of the field, the properties of the material and the parameters of the shell. A system of equations is given that describes the zero-moment state corresponding to a heat field with zero index of variability in the case of a continuous change in thickness. Solution of the thermoelasticity problem in the quasistatic approximation is considered in the case of thermal shock. Analysis of the results and numerical calculations show that with passage of time there is an expansion of the zone of extension and a reduction in intensity of the thermal boundary layer. The solution of the thermoelastic problem contains wave components due to the temperature conditions on the end, the nature of the thickness variation and the taper of the shell. Figures 2, references 2 Russian.
[176-6610]

UDC 624.074.4

DESIGN OF RETICULAR SHELLS OF REVOLUTION

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 17, No 7 Jul 81 (manuscript received 26 Apr 79) pp 53-60

PONOMAREV, V. V. and BELIKOV, G. I., Volgograd Engineering-Design Institute

[Abstract] The static design of reticular shells of revolution is considered as a linear problem. The carrier structure of such a shell consists of rigidly coupled beams forming an array which can be regarded as a structurally anisotropic continuous shell. From the equations of the linear theory of thin elastic shells,

the corresponding equations of equilibrium and expressions which relate strains to displacements of the median surface are derived in a cylindrical coordinate system. All beams are assumed to be made of the same material, but the cross-sections of oblique members are different than those along parallels and meridians. Upon separation of variables, the independent systems of eighth-order ordinary differential equations for each harmonic are reduced to a Cauchy boundary-value problem easily solvable by the Runge-Kutta method of numerical integration. Three kinds of edge constraints are considered here: clamping, hinging, and free support. A program has been written in ALGOL-60 for such a design of conical and cylindrical reticular shells. Figures 3, references 9 Russian.
[201-2415]

UDC 539.3:534.1

RESONANCE VIBRATIONS OF SHELL WITH INTRICATE OUTLINE RESULTING FROM BENDING BOUNDARY OF ELLIPSOID OF REVOLUTION

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 17, No 7 Jul 81 (manuscript received 26 Feb 79) pp 48-52

POPOV, A. L. and SOLODILOV, V. Ye., Institute of Problems in Mechanics, USSR Academy of Sciences, Moscow

[Abstract] For the purpose of analyzing the vibration spectrum of a shell of any shape whatever, the feasibility is considered of mapping such a shell by bending onto a not very different surface of a shell of revolution. This approach is studied on the basis of theoretical relations for an ellipsoid of revolution in Cartesian coordinates, utilizing the invariance of the first quadrature form of its surface and the invariance of its Gaussian curvature, as well as on the basis of experimental results pertaining to two originally identical ellipsoidal shells, one of which has been deformed by bending. The results indicate also the feasibility of holographic interferometry for determining the resonance vibrations of shells of intricate shapes. This is particularly applicable to convex shells. Figures 4, references 3 Russian.
[201-2415]

UDC 539.3

OPTIMAL CONTROL OF STRESS AND STRAIN STATE FOR VISCOELASTIC CYLINDRICAL SHELL

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 17, No 7 Jul 81 (manuscript received 9 Apr 78) pp 42-47

SHABLIY, O. N. and ZARETSKIY, V. I., Ternopol' branch, L'vov Polytechnic Institute

[Abstract] Induction heating of an isotropic viscoelastic shell is considered with optimal control of its state of stress and strain, i.e., with removal of residual stresses. Assuming a heater with distributed power above the shell surface, the equations of equilibrium are set up involving tensors of tangential forces, shearing forces, and moments. The functional serving as the measure of the stress level is selected in the form of a double (surface and time) integral and minimized by the Lagrange variational method. A solution is obtained for the specific case of an open cylindrical shell of finite length in an axisymmetric temperature field. The results indicate that the state of stress and strain can be controlled through the temperature field. Figures 4, references 5 Russian. [201-2415]

UDC 539.3

THREE-DIMENSIONAL PROBLEMS IN THEORY OF ELASTICITY FOR MULTILAYER SHELLS WITH NEARLY SPHERICAL INTERFACES

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 17, No 7 Jul 81 (manuscript received 22 Jul 80) pp 23-29

NEMICH, Yu. N., Institute of Mechanics, UkSSR Academy of Sciences, Kiev

[Abstract] Three-dimensional boundary-value problems in the theory of elasticity involving cylindrical multilayer shells with noncanonical interfaces have been considered in an earlier study. Here such a problem, namely determining the state of stress and strain with given displacements or stresses at the surfaces, is solved for thick multilayer shells of revolution with orthogonal and with nearly spherical nonorthogonal interfaces. In the latter case the solution of the problem reduces to successive solution of corresponding boundary-value problems for spherical multilayer shells. Figures 2, references 6 Russian. [201-2415]

UDC 539.374

NUMERICAL METHODS OF ANALYZING STATE OF STRESS AND STRAIN AND LIFE OF DISKS IN GAS-TURBINE AIRCRAFT ENGINES

Kiev PROBLEMY PROCHNOSTI in Russian No 4, Apr 81 (manuscript received 24 Apr 79) pp 49-55

DEM'YANUSHKO, I. V. and TEMIS, Yu. M., Moscow

[Abstract] For design purposes, the state of stress and strain of disks in gas-turbine aircraft engines can be analyzed by numerical methods with the aid of a computer. The conventional method for this application is based on reducing the differential equations to integral ones and solving the latter by iterations. Various calculation schemes have been developed for reducing the errors introduced by treatment of disks on heavy hubs as thin plates and shells. Here typical results are shown obtained by the finite element method (a disk subdivided into 245 nodes of 387 triangular elements with a linear approximation of displacements within an element) and by design calculations either for tension only in the elastoplastic region in a generalized plane state of stress or for tension and flexure with centrifugal loads also taken into account. Appropriate expressions have been derived for stress concentration factors, and anisotropic hardening due to nonisothermal loading has been analyzed according to the theory of plastic flow. Design for transient loads according to this theory by the step method is difficult and requires a self-correction algorithm. The life of disks is estimated on the basis of stress concentration factors and defect pile-up; changes in the mechanical characteristics of the disk material during operation must be taken into account, best by comparison with tested samples or with the aid of empirical relations when not enough test data are available. Figures 5, tables 2, references 33 Russian. [195-2415]

UDC 534.231

STATE OF STRESS AND STRAIN OF SPHERICAL SHELL UNDER NONSTEADY WIND LOAD

Kiev PROBLEMY PROCHNOSTI in Russian No 4, Apr 81 (manuscript received 16 Jan 80) pp 42-46

BOCHKOVSKIY, V. S., YEMEL'YANENKO, V. V., KARPOV, N. I. and FEDOTKIN, I. M., Kiev Polytechnic Institute

[Abstract] For engineering design purposes, the state of stress and strain of a spherical shell under a nonsteady wind load is calculated according to the general theory of shells. The wind pressure is resolved into two components: the average static one and the dynamic one due to irregular velocity fluctuations. The problem is solved not on the basis of the theory of random processes but, rather, through characterization of the properties of a linear system by its

response to elementary actions and subsequent use of the superposition method with Fourier series. Only the action of the effective peak pressure in a pulse of empirically established shape and duration needs to be examined. The problem is solved by introducing the equation of equilibrium, applying the Laplace transformation, and calculating the displacements. For illustration, the critical load is found for truncated spherical shells with rigidly clamped edges. Figures 2, references 6 Russian.
[195-2415]

UDC 539.432+620.278.3+620.193+620.194.8+621.438+621.515

EFFECT OF SERVICE IN CORROSIVE MEDIUM ON COMPRESSOR BLADE ENDURANCE IN GAS-TURBINE ENGINE

Kiev PROBLEMY PROCHNOSTI in Russian No 4, Apr 81 (manuscript received 29 Apr 80) pp 5-10

TROSHCHENKO, V. T., PROKOPENKO, A. V., TORGOV, V. N., BAUMSHTEYN, M. V. and GETSOV, L. B., Institute of Strength Problems UkSSR Academy of Sciences, Kiev

[Abstract] An experimental study was made to determine the effect of operation in sea water on the fatigue strength of guiding and moving blades in compressors of gas-turbine ship engines. Both new blades and blades after 12,000-16,000 h of service were tested in brine and in air. The blade materials were: 20Kh13, Kh17N2, grade-A steel for the entrance and first guiding stages, 1Kh12N2VMF steel for the first and second moving stages. They were cyclically loaded at frequencies from 490 to 640 Hz, then examined for corrosion and fatigue defects. The data, evaluated statistically according to the 5% Fisher criterion and by the method of least squares, fit the empirical relation for blade life $N = A \cdot 10^{B\sigma_a}$ (N--number of cycles before fracture, σ_a--amplitude of alternating nominal flexural stresses, A and B constants), they also yield coefficients characterizing the influence of technological defects and of technological+service defects. The results based on 10^7 cycles indicate that brine reduces the endurance limit for new and old blades by 50 and 68% respectively, 1Kh12N2VMF steel being more vulnerable than the other grades of steel. This grade is, therefore, not recommended for marine engines. Grades A and 20Kh13 are most suitable for this application. Figures 6, tables 3, references 4 Russian.
[195-2415]

UDC 621.438-253.5:539.319

STATE OF STRESS OF CHROMIUM STAINLESS STEEL GAS-TURBINE BLADES

Moscow VESTNIK MASHINOSTROYENIYA in Russian No 6, Jun 81 pp 25-26

ANDREYEVA, V. D., engineer, ANISIMOV, M. I., candidate of technical sciences, NOVIKOV, Ye. V., engineer, and SEMENOV, B. N., engineer

[Abstract] The state of stress of a precision-forced working blade for a gas turbine, made of 20Kh13 steel, was examined after various manufacturing operations and treatment. The main object of interest was the most vulnerable zone, namely the thin exit edge. Residual stresses of the first kind and their depthwise distribution in the σ-Fe main phase were determined by the x-ray sin $^2\phi$ method and layerwise etching. The results of microstructural analysis and mechanical testing reveal that tempering at 720° C for 4 h almost completely relieves dangerous tensile stresses induced during simultaneous calibration and quenching. Shot blasting causes surface hardening with a retention of the residual stress distribution in deeper layers. Straightening shifts the maximum of tensile stresses deeper but also increases its magnitude, which can be reduced to safe levels by subsequent tempering at 670° C for 4 h with retention of small compressive stresses in the surface layer. Figure 1, table 1.
[193-2415]

UDC 62-251:534.242

RESONANCE TRANSITIONS OF ROTORS IN ELASTIC DAMPER BEARINGS

Moscow VESTNIK MASHINOSTROYENIYA in Russian No 6, Jun 81 pp 12-14

KEL'ZON, A. S., doctor of technical sciences, ZOBNIN, A. P., candidate of technical sciences, and NEYGEBAUER, I. N., engineer

[Abstract] A rotor mounted in two stationary isotropic elastic damper bearings is under consideration and its passage through critical speeds is analyzed with neither the gyroscopic effect nor the rotor deformability taken into account. The corresponding system of four equations of motion is formulated and solved in Cartesian coordinates with one axis passing through the centers of both bearings in the rotor equilibrium position. The two critical speeds and the minimum torque necessary for pulling through them are calculated for $B = m_0 l_1 (l - l_1)$ and $B \neq m_0 l_1 (l - l_1)$ (B - central equatorial moment of inertia of the rotor, m_0 - mass of the rotor, l - distance between bearings, l_1 - distance from the left-hand bearing to the center of mass) without damping and with weak or strong damping. The results indicate that reducing the stiffness of the bearings will reduce the pull-through torque. Figure 1, references 6: 4 Russian, 2 Western.
[193-2415]

ASYMPTOTIC APPROXIMATIONS FOR SOLVING VIBRATION EQUATIONS FOR SPHERICAL SHELLS

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: MEKHANIKA in Russian Vol 33, No 6, Nov-Dec 80 (manuscript received 28 Dec 79) pp 54-64

BAZILEVSKIY, S. V., Central State Scientific Research Institute for Planning, Research and Testing of Steel Structures and Bridges

[Abstract] The fundamental homogeneous equations of steady-state vibration for a spherical shell closed around parallels are solved exactly in associated Legendre functions and in asymptotic approximations, following separation of variables. Asymptotic expansions in Bessel functions near the poles and in trigonometric functions far from the poles are appropriately collocated. The effectiveness of such an approximation is demonstrated on the specific problem of natural axisymmetric vibrations of a spherical zone symmetric with respect to the equator and clamped around its edges. The characteristic equation contains only elementary functions and its solutions can be easily found in explicit form. The author thanks Doctor of Physical and Mathematical Sciences V. I. Malyy for helpful comments and suggestions. References 10: 8 Russian, 2 Western. [191-2415]

UDC 534.014

OPTIMIZING ESCAPEMENT MECHANISMS

Moscow MASHINOVEDENIYE in Russian No 3, May-Jun 81 (manuscript received 19 Feb 80) pp 26-35

KURITSKIY, A. M. and VOROB'YEVA, G. N., Moscow

[Abstract] The problem of optimizing the design of escapement mechanisms is formulated as one of finding the vector of optimum parameters which will ensure the maximum value of the target function, namely the maximum efficiency. The net efficiency, the "static" component minus the "dynamic" component, is equal to the ratio of work output (work input by the driving forces minus losses due to friction, inertia, impact, and loosening of kinematic links) to work input. Relations for the forces (torques) and angular displacements during the three stages of an escapement cycle are establiched from the geometry of the mechanism components. The efficiency is then calculated on this basis. Its maximization proceeds in three steps, two successive quasi-optimizations and one final optimization of 16 design parameters involved in the process and under three kinds of constraints. Results of actual calculations for standard escapement mechanisms, according to the algorithm constructed for this purpose, reveal that the maximum static efficiency will be reduced by the necessary clearance and release torque from the theoretical 80% down to 68.7-73.6%, depending on the size of the device, while the dynamic efficiency will increase by 16.7-18.1% above the invariable minimum 8.1-8.5% so as to yield a net efficiency of 41.5-49.5%. A 5% increase of efficiency in a clockwork mechanism should make it possible to either increase

the amplitude of the balance wheel oscillations by 20° within the 150-270° range with the same drive torque or to decrease the drive torque by 10% for the same amplitude. Figures 3, tables 3, references 8 Russian.
[199-2415]

UDC 534.014.5

EFFECT OF NORMAL VIBRATIONS ON FRICTION FORCE MAGNITUDE

Moscow MASHINOVEDENIYE in Russian No 3, May-Jun 81 (manuscript received 19 Feb 80, after completion 29 Dec 80) pp 23-25

IVLEV, V. I., Moscow

[Abstract] Analytical relations are derived describing the dependence of the friction force in a couple not only on the contact stiffness but also on the amplitude and the frequency of superposed vibrations. A friction couple is considered which consists of a smooth solid body and a rough surface. The microstructure of the latter comprises, as a model, spherical segments of the same radius. The deformation is assumed to be purely elastic and to obey Hertz law. The equation of vibrations due to the stiffness of microprojections with a linear coefficient of viscous friction is solved by the method of successive approximations, whereupon the total area of true contact is calculated assuming a uniform density of microprojections and a power-law distribution of their heights. The load as a function of the convergence is expressed in the form of a Taylor series, and the friction force (principally due to adhesion) becomes the sum of two components. One proportional to the contact area and one proportional to the load, with the respective coefficients depending on the materials of the couple. References 5 Russian.
[199-2415]

UDC 534.141:518.5

IDENTIFICATION OF MECHANICAL OSCILLATING SYSTEMS

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian No 5, May 81 (manuscript received 23 Oct 78) pp 36-39

TUMANOV, Yu. A., candidate of technical sciences, docent, MARKOV, Ya. G., engineer and LAVROV, V. Yu., graduate student

[Abstract] The method of identifying mechanical oscillations of systems that reduce to digital models used in investigating the impact strength of a structure was considered. The mass, stiffness and damping parameters of the model were found from experimental results of the responses of a structure to given effects. Correct selection of the excitation function is vital when using the method. Figure 1, references 5: 4 Russian, 1 Western.
[189-A-6521]

UDC 539.3

CALCULATING SHELLS OF REVOLUTION BY FINITE ELEMENT METHOD

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian
No 5, May 81 (manuscript received 5 Jul 79) pp 26-31

BANDURIN, N. G., candidate of technical sciences, docent, NIKOLAYEV, A. P., candidate of technical sciences, docent, and APRAKSINA, T. I., senior instructor

[Abstract] An algorithm for formation of the stiffness matrix of an element is considered in the form of an arbitrary curvilinear rectangle on the median surface of a shell of revolution. The geometric values approximated inside the element are calculated directly from the surface equation upon numerical integration. Three components of the displacement vector and their first derivatives for angular and axial coordinates are taken as the angular parameters in the calculations. A series of matrix equations is derived to numerically integrate the required geometric values along the surface of the element from the equation of the meridian. Two examples of calculation are given for a long cylindrical shell and for two long cylindrical composite shells with a single radius of median surfaces. Figures 3, references 7: 4 Russian, 3 Western.
[189-A-6521]

UDC 539.3:518.12:624.074.4

DESIGNING SHELLS OF MINIMUM WEIGHT AND GIVEN VOLUME

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian
No 5, May 81 (manuscript received 29 Sep 79) pp 23-26

STOLYARCHUK, V. A., candidate of technical sciences

[Abstract] A zero-moment shell of variable thickness loaded by nonuniform internal pressure and formed by rotation of a curve around the x axis was considered to find the wall thickness and shape. The isoparametric problem is reduced to a variational type with inequality restrictions for a shell of revolution of minimum weight and given volume. The method of local variations at different points of the shell is used for numerical calculation. Figures 2, references 2 Russian.
[189-A-6521]

UDC 624.074

BOUNDARY-VALUE CONDITIONS AT POLE OF SHELL OF REVOLUTION DURING COMPUTER CALCULATION

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian
No 5, May 81 (manuscript received 17 Sep 79) pp 19-23

SUKHOVA, N. A., candidate of technical sciences, docent

[Abstract] The small circumference of the pole of a shell was replaced by a round plate of constant thickness to investigate the stress-strain state of a shell of revolution and precise solutions were used for the calculation. Systems of eighth-order ordinary differential equations were derived to calculate the boundary-value conditions at the pole of a shell of revolution of variable thickness. There was no concentrated load at the pole of the shell and the initial value of the independent variable was assumed equal to a small number upon integration. References 7 Russian.
[189-A-6521]

UDC 621.981

ANALYSIS OF TWO METHODS OF LOCAL DEFORMATION

Kazan' IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian
No 1, Jan-Mar 81 (manuscript received 11 Dec 78) pp 87-92

YERSHOV, V. I.

[Abstract] Increasing the size of sheaths and monolothic panels in aircraft structures requires larger processing rigs and tools, but this can be avoided by resorting to local deformation. Here two methods of local deformation are considered for a strip or a monolithic panel with longitudinal reinforcing ribs, such a deformation being caused by insertion of a cylindrical tool into a plastic blank. One method is squeezing the blank between a cylinder and a plate, another method is squeezing it between two rotating cylinders. Each of these methods is analyzed here in terms of displacements and forces, on the basis of the kinematic relations and the Bunyakovskiy inequality as they apply to the particular configuration. Theoretical results have been verified by experimental data on panels of the D16AT aluminum alloy squeezed between two rollers in a DRM MATI mill. Figures 6, references 2 Russian.
[197-2415]

UDC 539.3.534.1

ANALYSIS OF TURBINE BLADE HIGH-FREQUENCY VIBRATIONS BY METHODS OF 'SLIDING SUPPORT' AND HOLOGRAPHIC INTERFEROMETRY

Kazan' IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 81 (manuscript received 4 Dec 79) pp 58-62

SHALABANOV, A. K.

[Abstract] A new method of determining the natural vibration frequencies and modes of deformable solid bodies is described which involves excitation by an electric source through a piezoelectric transducer and measurement on an oscillograph after conversion to electric signals by another piezoelectric transducer. A coupler sliding over the body surface is used for detuning the body as soon as resonance has been reached and for thus locating the nodal lines and antinodes. A movable point-contact support is used as the source of frequency and amplitude perturbations. This method is easily implemented in the laboratory and in the field, it is very sensitive to amplitude smaller than 10^{-4} mm and frequencies from 1 to 1000 kHz, it is universally applicable, with any kind of excitation to objects of any size and shape, and it is safe on account of the low excitation level it requires. The method was tested on turbine blades for an analysis of their high-frequency vibrations, one mounted as a cantilaver beam and one fixed at both ends. Its correctness has been established by comparison of the results with those obtained by holographic interferometry with subsequent time averaging. It is broader in scope, however, as it extends to higher-order harmonics and lower-level vibration amplitudes not detectable by holographic interferometry. Figures 3, tables 3, references 6 Russian.
[197-2415]

UDC 539.1

STRESSED STATE OF CYLINDRICAL TANK WITH TANGENTIAL BRANCH PIPE UNDER ACTION OF INTERNAL PRESSURE

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian No 4, Apr 81 (manuscript received 17 Feb 79) pp 11-14

BERKOV, N. A., assistant and SKOPINSKIY, V. N., candidate of technical sciences

[Abstract] A finite element method is used to analyze the stressed state of the weld between a large cylindrical tank and a tangentially placed branch pipe. A cylindrical rectangular element is used to approximate the shell surface with five degrees of freedom in the junction. In the calculation, the shells of tank and branch pipe are broken up into elements by lines coincident with the coor dinate lines of the cylindrical surfaces. In the vicinity of the intersection, the shells are approximated by quadrangular elements with two sides coincident with coordinate lines, the two others being geodesics that join three nodes

situated on the line of intersection. A considerably greater number of elements must be used for the tangential case than for radial joints. The stiffness matrix, displacement vector and load vector of the element are constructed in localized cylindrical coordinate systems fixed to the branch pipe and the tank. A computer program is compiled in FORTRAN-IV for YeS computers to calculate the stressed state of a weld between a tangential pipe and a tank under internal pressure. It is shown that maximum stresses arise on the inside of the tank and the outside of the pipe at the point of the weld farthest from the point of tangency, i. e. at the inside corner. The greatest stresses are typical of welds with a large ratio of shell radii, since the shell of the pipe will have a thinner wall in such cases. Figures 3, references 2: 1 Russian, 1 Western.
[177-6610]

UDC 539.3

SELECTING RATIONAL PARAMETERS OF REINFORCEMENT OF CYLINDRICAL SHELL IN ZONE OF CONCENTRATED ACTION

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian
No 4, Apr 81 (manuscript received 28 Jun 79) pp 15-17

POPOV, B. G., candidate of technical sciences, and UZHVA, V. V., engineer

[Abstract] An analysis is made of the problem of determining weight-optimum parameters of a circular rod of variable stiffness that reinforces a cylindrical shell in a zone of concentrated radial action. It is assumed that the radius, thickness and length of the shell and the width of the reinforcement are given. The problem is formulated as a nonlinear programming problem. The criterion function is the volume of material of the reinforcement, and the constraints are conditions of strength of the shell and the curvilinear rod. A finite element method is used to determine the stresses and strained state of the structure. It is shown that the proposed technique can reduce the wieght of reinforcement by a factor of ten as compared with a ring of fixed cross section ensuring the same strength. Zero-moment methods are not applicable to problems of this kind because of the considerable contribution of torque factors to the stressed state of the shell in the zone of the ends of the curvilinear rods. Figures 2, references 6: 5 Russian, 1 Western.
[177-6610]

UDC 539.32

THEORY OF COUPLED THERMOELASTICITY OF TWO-COMPONENT MIXTURES

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 17, No 6, Jun 81 (manuscript received 17 Jun 80) pp 21-28

KHOROSHUN, L. P. and SOLTANOV, N. S., Institute of Mechanics, UkSSR Academy of Sciences, Kiev

[Abstract] Description of mechanical and thermal processes in two-component elastic media based on the principle of "homogenization" of an inhomogeneous medium assumes that the characteristic distances at which changes of parameters take place are much greater than the characteristic dimensions of inhomogeneities. This enables introduction of parameters that are average over elementary macrovolumes, and description of processes in a space with points that simultaneously contain both components in proportion to their volumetric content. Two approaches are possible. The first and simpler is based on the method of "effective" properties, in which the macroscopic parameters are stresses, deformations, displacements, thermal fluxes and temperature that satisfy the classical equations of thermoelasticity. The problem in this case reduces to determination of the effective characteristics for the given structure of the inhomogeneous material. The second approach is based on studying the average parameters with respect to each component in the elementary macrovolume. In this case, the number of parameters is doubled, and equations of conservation of momentum and heat are constructed for each component. The main problem is closure of the equations and determination of the coefficients from the predetermined structure of the medium and properties of the components. In a previous paper, L. P. Khoroshun derived equations of motion of interpenetrating mixtures, found the nature of relations between dynamic and kinetic parameters, and determined the coefficients of the equations. In this paper, the authors generalize this construction to the case of coupled mechanical and thermal processes. The analysis applies to a mechanical mixture of two elastic components, assuming that only mechanical and thermal processes occur. A system of equations of the coupled two-temperature problem of thermoelasticity is derived for an isotropic medium of granular structure. These equations of coupled thermoelasticity are used to study plane harmonic thermoelastic expansion waves in an infinite two-component composite of granular structure. The influence that the temperature difference of phases has on the behavior of wave processes in two-phase elastic mixtures is studied by assuming that the phase displacements are the same, and the temperatures of the phases are different. The results of the analysis show that a two-temperature formulation is necessary for solving a certain class of problems of thermoelasticity of two-phase elastic mixtures. Figures 2, references 7 Russian.
[190-6610]

UDC 539.4:534.134

FORCED OSCILLATIONS OF VISCOELASTIC CYLINDER REINFORCED BY SHELL WITH ANNULAR RIBS

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 17, No 6, Jun 81 (manuscript received 24 Jan 79) pp 29-35

MALYUTIN, I. S. and NEDBAY, A. Ya., Moscow

[Abstract] An analysis is made of the stressed and strained state of a system made up of a viscoelastic isotropic hollow cylinder and an orthotropic shell discretely reinforced with annular ribs under the influence of a harmonically varying distributed external load. The motion of the shell with hinged support on the end faces is described by equations of the general moment theory. For the cylinder, equations of the three-dimensional theory of elasticity are used, that are solved by the Lamé method. The viscoelastic properties of the cylinder are accounted for by introducing a complex modulus of elasticity. For arbitrarily placed unidentical ribs the problem reduces to solution of a system of algebraic equations relative to the amplitude values of two components of displacements at points of rib placement, the number of unknowns being equal to twice the number of ribs. An example is given of calculation of the stressed and strained state of an orthotropic shell reinforced by a viscoelastic cylinder and a rib located in the middle cross section. Figures 4, references 6 Russian.
[190-6610]

UDC 539.319

ELASTIC DEFORMATION AND SLIPPING OF LAYERS OF CYLINDRICAL SHELL FORMED BY COILING UNDER LOADING BY INTERNAL PRESSURE

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 17, No 6, Jun 81 (manuscript received 18 Mar 80) pp 59-63

IL'IN, L. A. and LOBKOVA, N. A., Institute of Mechanics, UkSSR Academy of Sciences, Kiev

[Abstract] The authors consider a multilayered cylindrical shell in the form of a coil rolled in an Archimedes spiral. The edges of the coil are secured to the surface of the shell so that the inside and outside turns are closed. It is assumed that there are no initial stresses or gaps between turns. The shell is loaded by internal pressure without partial relief in the loading process. The total thickness of the shell is taken as small compared with the radius. An analysis is made of the slipping between turns and the stressed and strained state of the shell as a function of the coefficient of friction. It is shown by a numerical example that slipping leads to appreciable redistribution of forces in the layers as compared with the case where they are working together. Figures 2, references 3 Russian.
[190-6610]

UDC 539.3

FREE OSCILLATIONS OF RIBBED CYLINDRICAL SHELL WITH FRAME

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 17, No 6, Jun 81 (manuscript received 15 May 79) pp 64-70

PALAMARCHUK, V. G., Institute of Mechanics, UkSSR Academy of Sciences, Kiev

[Abstract] An analysis is made of a system consisting of a ribbed cylindrical shell regularly reinforced by stringers and bulkhead frames, and including a square closed frame inside the shell and secured at the corners. It is assumed that the shell is thin, and its stressed and strained state is described by relations based on Kirchhoff-Love hypotheses. The ribs and frame elements are calculated by formulas for the strength of materials. The ribs in one direction are identical, as are the elements of the frame. Thus the system has two diametric planes of symmetry. The problem of determining the natural frequencies of oscillations of the system is solved by an energy method in the linear approximation. The discrete arrangement of the reinforcing ribs is taken into consideration. It is found that the first natural frequency of the symmetric mode of oscillations is higher than the first natural frequency of the inversely symmetric mode. Apparently the stiffness of the frame shows up more in the former case, and its inertia shows up more in the latter case. Figures 4, references 4 Russian. [190-6610]

UDC 539.3

STABILITY OF CYLINDRICAL SHELL INTERACTING UNILATERALLY WITH WINKLER BASE

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 17, No 6, Jun 81 (manuscript received 12 Mar 80) pp 71-75

BAZHENOV, V. A., GOTSULYAK, Ye. A., GULYAYEV, V. I. and OGLOBLYA, A. I., Kiev Construction Engineering Institute

[Abstract] Most of the research that has been done on the stability of cylindrical shells in contact with an elastic medium under the action of uniformly distributed radial pressure has been based on the hypothesis that there is no separation between the shell and the base. This condition does not always correspond to the actual situation and may considerably alter the magnitude and form of loss of stability. In this paper the authors examine the problem of stability of a

cylindrical shell under uniformly distributed radial pressure and unilaterally interacting with an elastic base or filler. An investigation is made of the influence that separation has on the critical load and the form of loss of stability. The model of the elastic medium is a Winkler base that can resist "indentation" of the shell, but is incapable of resistance to separation. This condition considerably complicates solution of the problem since the unknown quantity is the configuration of the zones of contact between shell and filler. The analysis is based on the equation of stability of a circular cylindrical shell with a filler in the zero-moment subcritical state. It is found that consideration of unilateral contact considerably reduces the critical load as compared with the solution that assumes bilateral connection between the shell and the elastic medium. The greater the rigidity of the elastic base, the more appreciable will be the reduction in the critical load. The thickness of the shell also has a considerable effect on the critical load. The influence of unilateral contact on critical pressure is greater for thin shells. Accounting for unilateral contact also has a considerable effect on wave formation. When the coefficient of stiffness of the elastic medium is low, the areas of separation and contact are equal. Increasing stiffness of the base narrows the zones of separation and widens the zones of contact with the medium. Figures 3, references 4 Russian.
[190-6610]

UDC 539.3

INVESTIGATING STRESSED STATE OF SHEAR-COMPLIANT CYLINDRICAL SHELLS OF ARBITRARY CROSS SECTION

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 17, No 6, Jun 81 (manuscript received 17 Jul 80) pp 131-134

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[Abstract] Noncircular cylindrical shells with variable geometric, mechanical and thermophysical parameters are extensively used as structural components in engineering equipment. Hypotheses that are less rigorous than those of nondeformable normals are needed for calculating such shells when they are made of new composites that have low shear stiffness, considerable anisotropy and inhomogeneity of mechanical and thermophysical properties, laminar shells with appreciably different characteristics of the layers, thick shells, and shells subjected to the action of rapidly changing loads. In this paper the stressed state of such shells is analyzed on the basis of the hypothesis of a straight line for the entire stack of the shell. In accordance with this hypothesis, a normal element that is initially perpendicular to the coordinate surface before deformation remains rectilinear after deformation, but no longer perpendicular to the deformed surface, being turned through a certain angle without changing length. Thin

orthotropic multilayered shells are considered that are closed along the directrix and subjected to nonuniform force loads and a temperature field. It is assumed that the shell rests on an elastic Winkler base, and that the layers work together without slipping or separation. The approach that is used is based on reducing the two-dimensional boundary value problem to a one-dimensional problem by expanding all unknowns in Fourier series with respect to longitudinal coordinate. The boundary value problem is solved by a discrete orthogonalization method. An example is given. Figures 3, references 6 Russian.
[190-6610]

UDC 539.3

ANALYZING COMPUTATIONAL SCHEMES FOR SHELLS OF COMPOSITE MATERIALS WITH OPENINGS

Kiev PRIKLADNAYA MAKHANIKA in Russian Vol 17, No 4, Apr 81 (manuscript received 30 Jan 80) pp 24-30

SHNERENKO, K. I., Institute of Mechanics, UkSSR Academy of Sciences, Kiev

[Abstract] The extensive use of shells made of composite materials as load-bearing structures has necessitated development of effective methods of calculating shell components. Structural inhomogeneity can be accounted for by existing methods of determining elastic characteristics of composites. Creep and other nonlinear rheological characteristics are generally taken into consideration by methods of successive approximation or small-parameter techniques in which the zero approximation is solution of the linearly elastic problem. In problems of composite shells with holes, the mathematical difficulties inherent in stress concentration problems in general are complicated further by questions of selecting computational schemes that adequately account for the enumerated properties of composites. This paper is a survey systematizing the state of the art in approaches to solution of problems for shells and plates of composite materials utilizing a variety of computational schemes, with analysis of their applicability to determination of the stressed state of structural components with openings. Recommendations are made on selecting computational methods for specific problems with consideration of type of material, anisotropy, shear between layers and so on. Figures 4, references 32: 31 Russian, 1 Western.
[176-6610]

UDC 539.3

NATURAL OSCILLATIONS OF LAMINAR ANISOTROPIC PLATES AND SHALLOW SHELLS

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 17, No 4, Apr 81 (manuscript received 27 Nov 79) pp 31-37

KUZNETSOV, N. D., KARTASHOV, G. G., RASSKAZOV, A. O. and SHUL'GA, N. A., Kuybyshev Aviation Institute, Kiev Motor Vehicle and Highway Institute, Institute of Mechanics, UkSSR Academy of Sciences, Kiev

[Abstract] In this paper the authors develop and generalize results of their previous research to the case of anisotropic laminar plates and shallow shells. The hypotheses on which the analysis is based enable theoretical consideration of effects due to transverse shear and compression of a shell. Rotational inertia is taken into account in the equations that describe natural oscillations. The Ritz method is used to solve problems of oscillations of cantilevered laminar anisotropic plates and cylindrical panels made of composite materials. An investigation is made of the effect that transverse shear has on the spectrum of natural frequencies of vibrations of such plates. The theoretical calculations are compared with experimental data. The results show a dense spectrum of natural frequencies of vibrations of thin-walled structural components made of composites. The proximity of the frequencies of certain modes of vibrations causes coupling, and interplay is observed in experiments. Figures 4, references 16: 15 Russian, 1 Western.
[176-6610]

UDC 539.3:534.1

NUMERICAL CALCULATION OF PIEZOCERAMIC SHELLS OF REVOLUTION

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 17, No 4, Apr 81 (manuscript received 25 Jan 80) pp 38-42

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[Abstract] A numerical analysis is made of a thin-walled piezoceramic shell of revolution of constant thickness. Covering the inner and outer surfaces of the shell are infinitely thin electrodes with infinite electrical conductivity to which a voltage is applied. The state of the shell material is characterized at every point by mechanical and electrical parameters: displacement vector, stress and strain tensors, vectors of electric field strength and electric induction, and electric field potential. It is assumed that the vector of preliminary polarization of the material coincides with the normal to the middle surface. Formulas are derived for calculating the stress-strain state of the shell, and a numerical example is given. Figure 1, references 7: 6 Russian, 1 Western.
[176-6610]

UDC 539.3

STRESSED STATE IN VICINITY OF CYLINDRICAL SHELL INTERSECTION

Kiev PRIKLADNAYA MAKHANIKA in Russian Vol 17, No 4, Apr 81 (manuscript received 11 Feb 80) pp 122-125

STREL'CHENKO, I. G., Institute of Mechanics, UkSSR Academy of Sciences, Kiev

[Abstract] The stressed state in the joining between two orthotropic cylindrical shells intersecting at right angles is analyzed on the basis of solutions of systems of differential equations derived in a previous paper [see O. A. Goroshko, I. G. Strel'chenko, "Stressed and Strained State in the Vicinity of Intersection of Cylindrical Orthotropic Shells of Constant Thickness", PRIKLADNAYA MEKHANIKA, Vol 12, No 3, 1976, pp 9-13]. The solution for the branch pipe is readily found from a system of differential equations with constant coefficients. The system of resolving equations for the main shell is solved by a perturbation method. The result is an infinite number of systems of equations for the branching shell, the main shell, and the conditions of joining. For computer solution, a program is written in BESM-ALGOL and FORTRAN for the BESM-6 computer. Machine time is 5-10 minutes. Stress distributions are compared for right-angle joinings of orthotropic and isotropic shells. Figure 1, references 3: 2 Russian, 1 Western. [176-6610]

UDC 622.74

CHOOSING MAIN PARAMETERS OF INCLINED VIBRATING SCREENS WITH CIRCULAR OSCILLATIONS

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 17, No 4, Apr 81 (manuscript received 26 Jan 79) pp 133-137

GROBOV, N. A., Volgograd Construction Engineering Institute

[Abstract] A theoretical analysis is made of the problem of screening in which the vibrational displacement of particles is utilized for separating particles of lower grade through the openings of a sieve rather than for transport. Steady-state motion of particles is assumed on the basis of visual observations and high-speed motion pictures. In this mode of motion, the process of particle displacement is stabilized, and for a relatively thin layer that ensures effective screening, this process is adequately described by the motion of a single particle if the influence of adjacent particles is accounted for by a force of viscous friction proportional to their relative velocity. The conditions of vibration screening, unlike those of vibrational transport, are characterized by negligible hysteresis losses in particles of displaced material, and collisions with the surface of the screen can be taken as instantaneous. Differential equations of motion are given for a particle relative to longitudinal and normal coordinate axes fixed to the plane of the screen in circular oscillatory movement. The region of

existence of a given type of steady-state motion of the particle is determined, and the problem of motion stability is studied. Expressions are found that can be used to determine optimum frequency and amplitude of oscillations, angle of inclination of the screen and the average velocity of particles from known values of the restitution coefficient and resistance to relative displacement of particles. References 3 Russian.
[176-6610]

UDC 621.787.621.921.34

TECHNOLOGICAL FEASIBILITY STUDY OF USING TITANIUM NICKELIDE FOR NEW TYPES OF PERMANENT PIPELINE JOINTS

Kazan' IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 81 (manuscript received 4 Dec 79) pp 49-52

KHVOROSTUKHIN, L. A., KHAS'YAMOV, U. and SHISHKIN, S. V.

[Abstract] A new type of permanent pipeline joint is sought for the aerospace industry, namely a connector made of a material with a thermomechanical "memory" allowing it to return to its original size and shape upon heating after an up to 8% deformation. Titanium nickelide (approximately equal amounts of Ti and Ni, alloyed with Co or Fe) with a transformation temperature within the 143-193 K range is such a material. A sleeve of this material is cooled to the liquid-nitrogen temperature, at which its original diameter is smaller than that of the pipe segments, then expanded so that it will clear the pipe segments and slipped over the ends of two such segments to be connected, whereupon it shrinks again as a result of natural heating to the ambient temperature and will tightly press the pipe segments together. Such joints have been tested to determine the dependence of the thermomechanical recovery stress on the preshrink clearance (0 - +2.4 mm) and on the predeformation (1-9% expansion), also the dependence of the static strength on the preshrink clearance and the effect of lubrication (paraffin, lead, cadmium) on the static strength. The best results were obtained with 2-6 μm thick film of cadmium as solid lubricant. The results of these tests indicate that such joints will be satisfactory and reliable at operating temperatures from 103 to 503 K. Figures 3, reference 1 Western.
[197-2415]

UDC 621.43.019.2:621.436

CYCLOHEXYL NITRATE: FUEL ADDITIVE FOR DIESEL ENGINES

Leningrad DVIGATELESTROYENIYE in Russian No 3, Mar 81 (manuscript received 29 Feb 80) pp 23-26

YEREMENKO, L. T., doctor of technical sciences, professor, POLYAKOV, G. D., candidate of technical sciences, BOLDYREV, I. V., candidate of technical sciences and GOL'TSOV, V. N. engineer

[Abstract] A fuel additive for vehicle engines must improve the flammability of gasoline in low concentrations, be highly soluble in gasoline, remain stable and nonvolatile in long storage, have no detrimental effects on engine life and performance. It must also be inexpensive and abundant, must be neither toxic nor explosive. These requirements are most closely met by cyclohexyl nitrate, used abroad but not produced in the Soviet Union. The major drawbacks of various methods of producing it are the insufficient purity (only 80-93%) of its basic ingredient and the insufficient yield (only 65-81%). A new method has been developed which results in an up to 98% yield of additive with a 99.9% pure basic ingredient. The process is not described here, but extensive product evaluation data are reported. The additive was tested with three grades of gasoline (AI-93, A-76, A-72) in amounts varied from 0.5 to 3%, in a variety of diesel engines (single-cylinder two-cycle and four-cycle, multicylinder four-cycle, compression ratio 15-16.5) for both start and run performance. The results of these tests are favorable, indicating that up to 2.5% of the additive improves the gasoline without affecting the normal diesel performance characteristics. Use of this additive will contribute to better transportation, will improve the vehicle performance in cold weather, and will provide a wider range of graded fuel blending for diesel vehicles.
[189-2415]

UDC 534.343

CHANGES IN SPECTRAL REFLECTION CAPACITY AND INTEGRAL ABSORPTION COEFFICIENT OF TiO_2 POWDER UNDER SIMULATED SOLAR RADIATION

Tashkent GELIOTEKHNIKA in Russian No 3, May-Jun 81 (manuscript received 2 Jul 80) pp 31-34

MIKHAYLOV, M. M. and DVORETSKIY, M. I., Scientific Research Institute of Nuclear Physics imeni S. M. Kirov, Tomsk Polytechnic Institute

[Abstract] A study was made of changes in the spectral reflection capacity and in the integral absorption coefficient of pressed rutile (TiO_2) powder due to irradiation from a xenon-arc lamp. Accordingly, for the purpose of analysis, the spectra of nonirradiated specimens are not subtracted from those of specimens which have been irradiated with a certain definite dose. The most appreciable

change in the spectrum is the appearance of a sharp induced absorption peak within the 800-1100 nm (near infrared) range and two easily resolvable soft induced absorption peaks at 440 and 500 nm (visible range) respectively. The integral absorption coefficient was found to change mostly within the first 8-12 h of irradiation and then to continue increasing at a much slower rate, as a fractional-power function of time. These changes are attributable to photolysis of titanium oxide, resulting in formation of oxygen vacancies and interstitial titanium. Figures 4, references 15: 9 Russian, 6 Western.
[187-2415]

UDC 662.997.004.14

METROLOGY OF SOLAR CELLS

Tashkent GELIOTEKHNIKA in Russian No 3, May-Jun 81 (manuscript received 5 Jan 81) pp 3-13

KOLTUN, M. M. and ORSHANSKIY, I. S., "Order of Labor's Red Banner" All-Union Scientific Research Institute of Current Sources

[Abstract] The major aspects of measurements pertaining to solar cells and batteries for spacecraft or ground applications are reviewed in this "state of the art" survey. The performance characteristics of solar devices are measured using either simulators, special lamps with auxiliary optics, or less often the natural solar radiation directly. Various simulators have been developed and are available, along with reference standards of solar devices and methods of their calibration. While the problem of performance stability has been virtually solved, it is still necessary to continuously monitor the accuracy of measurements and to minimize their error. Further progress in measurement techniques is expected to follow new achievements in the device technology. Figures 2, table 1, references 65: 33 Russian, 32 Western.
[187-2415]

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